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SUMMARY REPORT ON WATER POLLUTION, MISSOURI RIVER DRAINAGE BASIN. A COOPERATIVE STATE-FEDERAL REPORT ON WATER POLLUTION

Public Health Service
Kansas City, Missouri

1951

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For Clean Water—"One River, One Plan"

Missouri River

DRAINAGE BASIN

A COOPERATIVE STATE-FEDERAL REPORT ON WATER POLLUTION

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Public Health Service

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SUMMARY REPORT ON WATER POLLUTION

Missouri River Drainage Basin

Prepared by

FEDERAL SECURITY AGENCY
Public Health Service
Division of Water Pollution Control
Missouri River Drainage Basin Office

1951

In cooperation with -

Colorado Department of Public Health
Committee on Water Pollution of the
State of South Dakota
Iowa State Department of Health
Kansas State Board of Health
Minnesota State Board of Health
Missouri Division of Health
Montana State Board of Health
Nebraska Department of Health
North Dakota State Department of Health
Wyoming Department of Public Health

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INTRODUCTION

The Federal Water Pollution Control Act, Public Law 845, passed by the 80th Congress in June of 1948, requires the Surgeon General of the Public Health Service to cooperate with other Federal agencies, with State and interstate water pollution control agencies, and with municipalities and industries in the preparation or adoption of comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof, and improving the sanitary condition of surface and underground waters.

In developing these programs, due regard must be given to improvements necessary to conserve the Nation's waters for public water supplies, propagation of fish and aquatic life, recreational purposes, agricultural, industrial, and other legitimate uses.

Recognizing the fact that full technical information was not available to permit the development of such comprehensive programs immediately for most of the Nation's waters, the Public Health Service envisioned the development of these programs in two general phases. The first phase contemplated the development of a series of reports, consistent with presently available data, which would: provide a reference point for measuring progress; provide a guide to needed additional data; provide a basis for the logical development of comprehensive programs; provide a basis for approval of loans to States, interstate agencies and municipalities at such time as the Congress made available funds for this purpose; and serve to inform the public on the problem of water pollution and set forth suggestions for pollution control.

The collection of available data as of July 1, 1950, has been completed under the first phase of the program. Such data have been assembled with the cooperation of State and interstate water pollution control agencies. Through these agencies additional data have been obtained from other State officials, county and city officials and representatives of industry. Federal agencies also have been of great assistance. In order to make this information available at the earliest possible moment, these data are being presented in 15 summary-type reports covering the United States by major drainage basins. This report on the Missouri River Basin is one of that series.

These summary reports present information about the ways our water resources are used, the pollution going into our water resources and the resulting damages, the benefits which may result from pollution prevention and abatement, the pollution prevention measures now in effect, and those required.

They are prepared in two parts. Part one considers the water pollution problems of the basin as a whole. Part two presents briefly the data for each of the several sub-basins of the major basin, including a list of projects now known to be needed for water pollution control.

Since the summary reports are based on data which are now readily available, these reports do not discuss or evaluate the most advantageous water uses as they are related to pollution control. Such considerations will be included as a part of the comprehensive water pollution control programs.

The deficiencies in data and the gaps in information indicated in these summary reports are as significant as the presentation of available facts and statistics. They indicate the work which still needs to be accomplished by water pollution control authorities for the preparation of comprehensive programs.

Data and knowledge now available are sufficient, however, to permit the immediate solution of many of the pollution problems within the Missouri Basin without awaiting the results of additional surveys and studies. The tabulations of pollution abatement projects which are included in Part Two of this summary report represent presently known needs. However, future studies and evaluations may result in some changes in the estimations of requirements.

A sincere effort has been made by all who contributed to this report to present a fair picture of the complex water pollution problems in the Missouri Basin and to present reasonable conclusions and recommendations. It is our hope that this report, as a step in the cooperative development of an ultimate comprehensive pollution control program, will help in safeguarding the water resources of the Missouri Basin.

Leonard A. Scheele
Surgeon General

ACKNOWLEDGMENTS

The Public Health Service wishes to acknowledge the cooperation and assistance of those agencies and individuals that have contributed to the preparation of this report.

The water pollution control agencies of the States in the Basin, including the Colorado Department of Public Health, the Iowa State Department of Health, the Kansas State Board of Health, the Minnesota State Board of Health, the Missouri Division of Health, the Montana State Board of Health, the Nebraska Department of Health, the North Dakota State Department of Health, the Committee on Water Pollution of the State of South Dakota, and the Wyoming Department of Public Health, have furnished the data from which the various tables were prepared and other data and information contained in the narrative statements. These agencies have also reviewed the preliminary draft of the report and have offered valuable comments and suggested changes. In general, the preliminary draft has been revised so that the report is in agreement with the comments and suggestions of the State agencies.

Federal agencies from which assistance was obtained include the Corps of Engineers, Department of the Army; the Bureau of Reclamation, the Fish and Wildlife Service, and the Geological Survey, Department of the Interior; the Department of Agriculture, and the Federal Power Commission. They have further contributed to the development of this report by their cooperation in reviewing the preliminary draft.

Finally, there is acknowledged the assistance of other State agencies and individuals interested in water resources development and conservation, that have contributed information through other sources than those listed above.

SUMMARY

The Missouri, longest of North American rivers, drains one-sixth of the United States. Contained within its Basin are parts or all of the States of Colorado, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, and Wyoming. Approximately 8,200,000 people live in the area and glean their livelihood from many sources. About 67 percent of the population live in cities and towns, and the remainder reside on the farms and ranches. The natural resources of the Basin are vast. The most valued are land and water. While up to the present time agriculture has been the backbone of the economy, there has been a slow and gradual trend towards industrialization.

Rivers have played a great part in the development of this large section of the Nation. They first provided transportation and later water for irrigation, water for power, and water for municipal and industrial uses. The economic development of the area is still in its infant stages, and future progress is closely allied with the development of the Basin's water resources. A part of that development is the protection of water resources from the inroads of pollution. Stream pollution is not acute in a Basin-wide sense, however there are numerous areas which have been plagued with rather severe local pollution problems.

Table 1 illustrates for comparative purposes the need for and progress toward abatement of municipal pollution in each Sub-Basin. This table is largely a summary of the interpretations given to the statistical data included in tables A, C, E, and G. It indicates that the Basin compares favorably with the national average in percent of municipalities with sewer systems having treatment, but is somewhat below the national average in percent of urban population in sewered areas served by treatment.

Fifty-three percent of the sewered population of the Missouri Basin is served with some degree of treatment in comparison to the Nationwide average of 62.7 percent. It is also evident from table 1 that only 18 percent of the sewered population for which treatment requirements are known is provided with adequate sewage treatment works. It will be noted that when compared on the basis of numbers of municipalities for which treatment requirements have been determined, instead of population, the percentage of adequate works increases to 52 per-

Table I - Summary of Missouri River Basin interpretative data-Municipal wastes

Sub-basin name	Number of treatment plants	Sewered population served by sewage treatment	Percent of municipalities* with sewer systems having treatment	Percent of sewered population served by treatment	**Percent of sewered population provided with adequate treatment	**Percent of treatment plants which are adequate	Number of municipal sources of pollution for which needs are undetermined
Upper Missouri--	25	41,700	66	34	51	37	15
Yellowstone -----	27	69,500	53	55	43	53	19
Missouri R. and Minor Tributaries, Ft. Peck to Spring Creek--	56	67,100	78	62	27	66	6
Missouri R. and Minor Tributaries, Spring Creek to James--	52	78,400	67	62	34	52	0
James ---------	27	74,800	61	85	8	40	0
Big Sioux--------	28	90,400	76	89	11	52	3
Lower Platte ----	39	138,000	48	56	14	47	1
North Platte-----	9	18,500	30	23	2	67	0
South Platte -----	39	581,600	73	92	5	16	2
Kansas---------	112	279,100	72	55	22	67	6
Lower Missouri--	193	328,300	67	26	18	51	29
Grand-Chariton--	39	43,000	78	74	21	26	0
Osage-Gasconade	43	65,100	93	90	43	58	0
Basin-------	689	1,875,500	67	53	18	52	81
U.S. average***	-	-	64.9	62.7	-	-	-

(Footnotes on page 6)

(Footnotes for Table 1)

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers, or other population centers; sanitary sewage wastes discharged by industry directly to watercourse.

** Values derived from known data only.

*** Excerpt from "Statistical Summary of Sewage Treatment in the United States" (1945).

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cent. The difference between 18 percent and 52 percent is due to the fact that most of the larger urban centers do not have sewage treatment works. The six sub-basins in which the percentage of sewered population provided with adequate treatment is lowest are, in ascending order, the North Platte, South Platte, James, Big Sioux, Lower Platte, and Lower Missouri.

Table 2 illustrates the summary of the data contained in tables B, D, and E. This table reveals that 30 percent of the industrial establishments discharging wastes directly to watercourses have treatment works. Column 4 indicates that 10 percent of the industries are known to be provided with adequate treatment facilities.

It is noted from tables A and B that the combined municipal and industrial wastes discharged into watercourses, in terms of equivalent numbers of people, are the wastes equal to 11,757,700 persons. Two-thirds of this waste load is discharged by industry and the remaining one-third is from the domestic population of the Basin.

From table G it is apparent that 356 new plants to serve 1,059,900 persons are needed, together with replacement of 56 existing plants and improvements to 181 others. The data also indicate that 70 new industrial waste treatment plants, 1 replacement and 13 enlargements of existing plants are needed to treat adequately industrial wastes now being discharged to watercourses. Existing data are insufficient to classify properly the treatment needs of 81 municipal systems and 85 industrial plants.

The report deals with only those municipalities with sewer systems, and with existing industries having separate discharge lines to watercourses. In addition to these present sources of pollution there are

Table 2 - Summary of Missouri River Basin interpretative data - Industrial* wastes

Sub-basin (1)	Number of industries* (2)	Percent of industries known to have - Treatment plants (3)	Percent of industries known to have - Adequate treatment (4)
Upper Missouri ---	17	18	0
Yellowstone -------	20	60	35
Missouri R. and Minor Tributaries, Ft. Peck to Spring Creek -----	- - - -	- - - -	- - - -
Missouri R. and Minor Tributaries, Spring Creek to James ----------	10	60	10
James ------------	4	25	25
Big Sioux ---------	5	60	40
Lower Platte ------	4	50	25
North Platte ------	14	36	7
South Platte ------	61	21	0
Kansas -----------	26	19	11
Lower Missouri ---	26	27	11
Grand-Chariton ---	1	0	0
Osage-Gasconade --	- - - -	- - - -	- - - -
Basin total -----	188	30	10

* Industries having separate outlets and discharging wastes directly to watercourse.

approximately 400 municipalities in the Missouri Drainage Basin which are potential sources of pollution. These are smaller cities and towns of 250 inhabitants and upward which do not at present have sewer systems, but which are now or in the near future may be planning such installations.

Most of the major streams of the Missouri River Basin may be classified as interstate streams. However, only a small percent of the number are carriers of excessive amounts of pollution from one State to another. These streams in which interstate pollution is of significance are the lower reaches of the South Platte and North Platte Rivers, the Big Sioux River, and the Lower Missouri River between Sioux City, Iowa, and Kansas City, Mo. The Kansas River, an intrastate stream, contributes a heavy load of waste at Kansas City, Kan., to the Missouri River.

It is difficult to estimate with accuracy the cost of pollution abatement in the Missouri River Basin.

On the basis of available data, which are admittedly incomplete, the total initial cost of required municipal and industrial waste treatment facilities is estimated to be $149,000,000. One hundred and fifteen million of this total is for the municipal requirements and $34,000,000 is for the industrial requirements. The municipal estimate includes treatment of industrial wastes now discharged to municipal sewerage systems and those which are amenable to treatment in municipal treatment plants. The industrial estimate reflects only those costs of treating industrial wastes now being discharged directly to streams and where there is little likelihood of their being treated in municipal treatment plants.

The data on existing facilities, stream conditions and needs for new plants or improvements to existing treatment works are subject to modification in those sub-basins where adequate investigational studies have not yet been made.

CONCLUSIONS

A review of the data contained in the report indicates the following conclusions:

1. The Missouri River Basin is so situated and so endowed with natural resources that it seems reasonable to anticipate an increase in industrial productivity, with a corresponding increase in the supporting population. It may be expected that the greatest growth will be in industries associated with the processing of agricultural materials, followed closely by those associated with the processing and refining of petroleum and related resources. In addition, it is quite likely that there will be a growth of various industries associated with the national defense program.

2. The basic data for the Basin as related to pollution are incomplete; however it is believed that the statistics contained in the report represent 92 percent of the project requirements affecting municipal treatment works. Data on industrial installation are less conclusive; however, about 55 percent of the project requirements have been classified. Investigation and study of industrial pollution are an urgent necessity. Integrated Basin-wide stream pollution studies are vital to the development of a comprehensive program of pollution control.

3. Pollution abatement progress in the Sub-Basins of the Missouri Drainage Basin is affected largely by three factors: (1) water available for the dilution of waste, (2) the uses to which water is put, and (3) the tools with which the pollution control agencies have been able to attack the problems of stream pollution.

4. Pollution abatement is inherently tied into the over-all Missouri River Basin Development Program. It seems logical to conclude that the regulation of stream flows will have a marked effect on the economics of sewage treatment. Great influence toward better pollution control will result from the increased number of recreational and fishing areas made possible by the Missouri River Basin Development Program.

5. Pollution is acute in localized areas within the Basin. The Sub-Basins where such acute conditions exist are the South Platte, the North Platte, the Big Sioux, the James, and to a lesser extent the

Lower Missouri. A review of the data indicates that it is in these Sub-Basins where the highest degree of treatment will be required to meet the needs of local water users.

6. It is apparent that most of the State Water Pollution Control Agencies within the Missouri River Drainage Basin favor a Basin-wide policy of providing at least primary treatment or its equivalent for all organic wastes originating within the Basin.

7. Benefits from a comprehensive pollution abatement program will probably be greatest in those areas where conditions are now critical. It is evident that, over much of the Basin, problems of pollution are largely local in effect and are generally confined to an area within 50 miles of the source of the pollution.

8. The interstate aspects of pollution appear to be pertinent in the Big Sioux Sub-Basin, and between Sioux City, Iowa, and Kansas City, Mo., in the Lower Missouri Sub-Basin. It will be necessary to establish uniform standards and control methods throughout these Sub-Basins before abatement programs can be entirely successful. The interstate aspects of stream pollution thus created in the Basin indicate that uniform legislation is a step toward uniform control.

9. Industries associated with processing of agricultural foodstuffs form the most numerous sources of industrial pollutants, with those associated with the production and refining of petroleum in second place. A further breakdown of the food processing industries indicates that meat packing plants contribute the greatest amount of organic waste (measured in terms of population equivalent units) followed closely by sugar refineries.

10. Industries with separate discharge lines to watercourses discharge approximately two and one-half times the pollution, measured in terms of population equivalent units, contributed by municipal systems. Thirty percent of industrial installations are provided with treatment facilities as compared to 67 percent of the municipalities. Ten percent of the industrial waste and 18 percent of the domestic waste is considered to receive adequate treatment. These comparisons are made on a Basin-wide level. The operation of the average municipal treatment facility appears to be somewhat better than the physical capacity of the plant to treat adequately the wastes.

11. One of the principal weaknesses of adequate sewage disposal in the Basin is the lack of competent, well-paid operators to assure satisfactory results from treatment installations.

12. Heavily polluted irrigation waters are being used extensively for truck crops in several areas within the Missouri River Basin.

13. Public interest in pollution control in the Missouri River Basin appears to be high. In general the public appears to support and favor a more vigorous program of pollution abatement than has prevailed in the past.

RECOMMENDATIONS

It is recommended that:

1. A uniform policy for the abatement and prevention of interstate pollution in the Missouri River Basin be developed by the Water Pollution Control Agencies representing the several States of the Basin. Such a policy should make possible the establishment of uniform standards and pollution control objectives and methods throughout the Basin.

2. Each State, where the need is apparent, take concerned action to secure adequate statutory support for the control of water pollution. This will include developing legislation containing adequate regulatory and enforcement provisions, together with the development of legislation and methods which will facilitate financing waste treatment works.

3. State governments more energetically support water pollution control programs by providing adequate funds for staffing and equipping the State Water Pollution Control Agencies.

4. Adequate treatment of sewage consistent with downstream water uses be provided by all municipalities now discharging untreated sewage to streams of the Basin, and additional treatment be provided where present facilities are inadequate.

5. Industrial wastes of organic type be given a similar degree of treatment to that recommended for near-by municipalities. Inorganic wastes should receive treatment compatible with downstream water uses and the maintenance in the streams of a balanced aquatic life. Complete removal of toxic industrial wastes from streams may be indicated, where such wastes deleteriously effect legitimate uses of water.

6. Sewage and industrial waste treatment plant maintenance and operation be sustained at a high level so that maximum returns may be realized from construction investments. Adequate short courses for operators by public health or educational institutions, frequent consultation and advisory service by State water pollution control agencies, and possibly licensing of operators should be considered as aids for improving the competency of plant operating personnel.

7. Caution be exercised in the use of sewage-polluted irrigation waters on low-growing truck crops that may be consumed uncooked. Chlorination of sewage treatment plant effluents discharged into irrigation waters should be given serious consideration.

8. The water resource development program of the Missouri Basin, being closely associated with problems of sewage disposal, give additional consideration in project design, as an integral portion of over-all planning, to allowances for sustained minimum flows compatible with adequate sewage treatment, provided such flows are available and consistent with considerations of maximum beneficial use of water resources of the Basin.

9. The State Water Pollution Control Agencies actively pursue a broad informational and reportorial program for the education of the public and industry in pollution prevention and abatement, the needs thereof, and benefits to be derived. Such steps should include public hearings, abatement orders, news releases, development of bulletins and articles for general dissemination, presentations before technical and civic organizations, and consultation with interested individuals or groups.

GENERAL DESCRIPTION

Historical Background

The Missouri River has been given many names. Historians sometimes refer to it as the River of Empire; the people who come in daily contact with it picturesquely call it Smoky Water, Big Muddy, or wild Missouri.

It is known from findings of archeologists that there were many successive types of Indian civilizations which occupied the various sections of the drainage area. From these findings, it is believed that many of the earliest inhabitants of the Basin were home builders and did a certain amount of farming. The mound builders typified this type of Indian civilization. Many of these mounds may still be seen in the Big Sioux and James River Valleys. There is also evidence in the area about the Black Hills of western South Dakota that a similar type of civilization existed there.

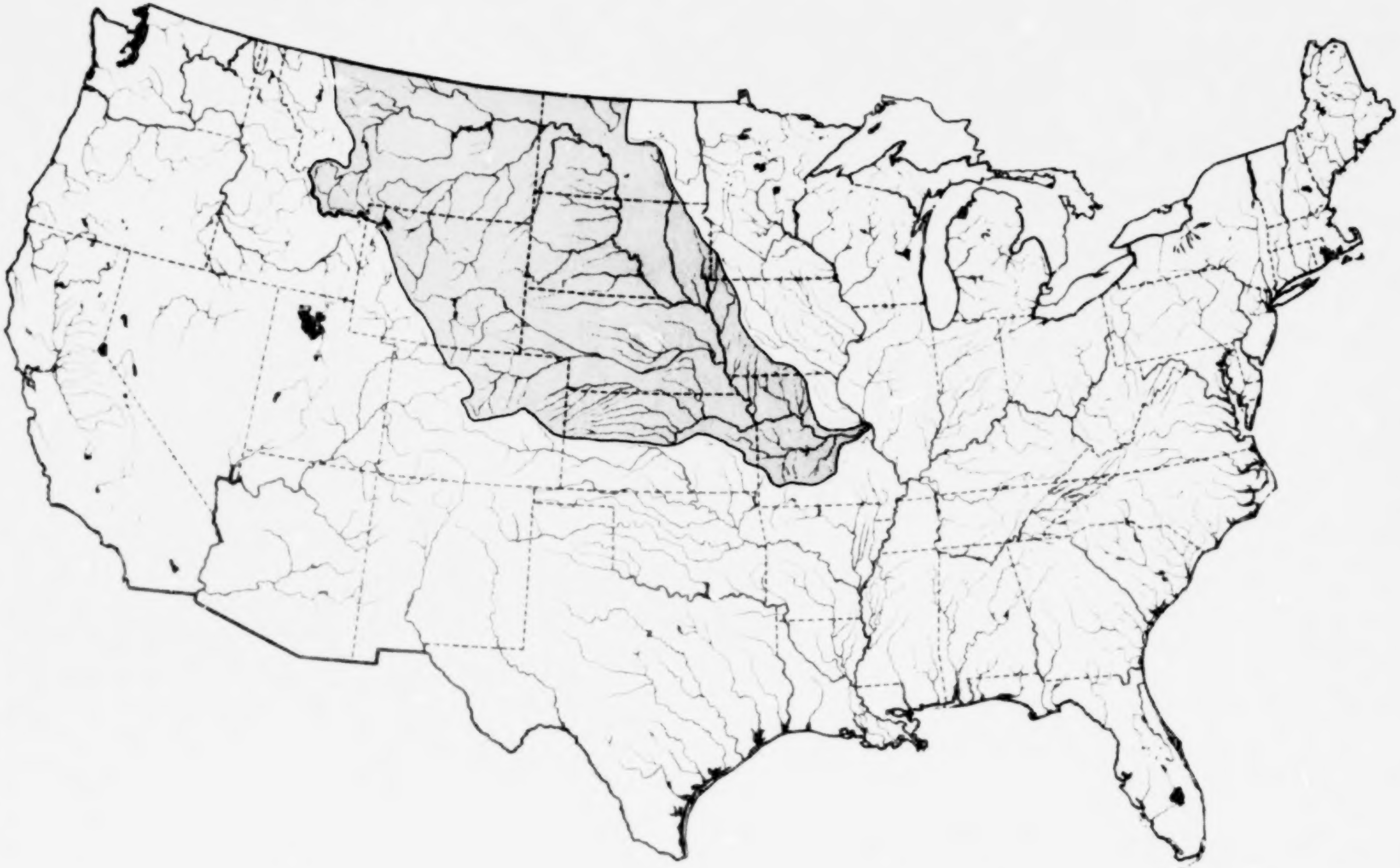
The domesticated Indians were displaced, driven off or absorbed by the roving tribes of warlike plains Indians whose existence was gleaned from the hunt. By the time the first white men visited the Missouri River the nomadic tribes of plains Indians were in possession of most of the region. Most famous among these tribes were the Dakota Sioux, the Cheyennes, the Pawnees, the Mandans, and the Blackfeet.

The first territory of the Missouri Drainage Basin to be visited by white men was central Kansas and central Nebraska. About 1540 the Spanish explorer Coronado visited this territory in his attempt to find the seven cities of gold. As far as it is possible to determine, white men did not again see this area until nearly 50 years later when two more Spanish explorers entered the same region. It is doubtful whether the Spanish explorers ever viewed the main stem of the Missouri River.

The first white men to see the mouth of the Missouri River were two French explorers, Father Marquette, and Joliet the trader, who reached the mouth in June 1673 on their journey down the Mississippi River. Father Marquette's log of the incident reveals that he was amazed by what he saw. "I have seen nothing more frightful, a mass of large trees, real floating islands, were issuing from the mouth of Pekitanoui." His Indian guides called the river "The Pekitanoui" meaning Muddy River. He renamed it the Missouri. The exact

LOCATION MAP

Missouri River Drainage Basin



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meaning of the word Missouri is still in doubt; however, it is believed that it was taken from the name of a tribe of Indians residing near the mouth at the time Father Marquette visited that area.

Shortly after Marquette's visit, La Salle explored the region, probably as far upstream as the mouth of the Grand River in Missouri. In 1714 another young Frenchman, Etienne Veniard de Bourgmound, followed the river probably as far as the mouth of the Platte. For these feats of exploration he was given a royal commission as "Commandant of the Missouri River," and thus the area drained by the river became French territory. It was originally called Illinois, but later became known as Upper Louisiana.

In 1803 President Jefferson, in order to determine what kind of territory had been purchased, commissioned William Clark and Meriwether Lewis to explore the region and to attempt to find a passageway to the Pacific Ocean. The Lewis and Clark report was the first official record made of the territory drained by the Missouri River.

Prior to the Lewis and Clark Expedition, however, numerous French fur traders had entered these regions and had established a lucrative trade with the Indians in many sections of the Upper Basin. The river provided these early traders with the means of transportation they needed to maintain their outposts.

During the ensuing part of the Nineteenth Century the river became a vast artery of commerce. Steamboats in great numbers plied the river from St. Louis to the mouth of the Yellowstone, carrying enormous volumes of commerce and great numbers of passengers. In the covered wagon days thousands of wagons traveled on boats from St. Louis to Kansas City or St. Joseph before their wheels touched the grass of the great plains. It was in this era that the settling of the West began. Among the great mass emigrations of this period was the movement of the Mormon peoples across the Basin into Utah and the emigration from the East to California caused by the gold rush. In addition to these mass movements there was a steady flow of immigrants into the Basin itself where they were privileged to acquire land under the Homestead Acts. Following the Civil War, the railroads, with their ribbons of steel, reached across the Missouri River and began to fan out in several directions across the plains.

Physical Description

Geography - The Missouri River Basin lies between the 90th and 114th meridians west, and between the 37th and 50th parallels north. The area, with a maximum width of 700 miles and a length of 1,300 miles, occupies parts or all of the States of Montana, Wyoming, Colorado, North Dakota, South Dakota, Nebraska, Iowa, Kansas, Missouri, and Minnesota. It encompasses 530,000 square miles, of which 521,000 square miles lies in the United States, and the remaining 9,000 square miles in the Dominion of Canada. It represents about one-sixth of the entire land surface of the United States. Natural boundaries are formed by the Rocky Mountains Uplift on the west, the Hudson Bay Drainage Basin to the north, the Mississippi Drainage Basin on the east, and by the Ozark Uplift and the Arkansas River Basin to the south.

Topography - The main stem of the Missouri River, formed by the junction of the Jefferson, Gallatin, and Madison Rivers near Three Forks, Mont., extends 2,550 river miles to its confluence with the Mississippi at a point just above St. Louis, Mo. Together with the Lower Mississippi River it forms the third longest river system in the world, while the Missouri alone is the longest river in North America. The major tributaries of the Missouri include the Yellowstone, the Platte, and the Kansas Rivers. Numerous other tributaries flow into the river throughout its entire length. The headwaters of the main stem, the Yellowstone, North and South Platte Rivers rise along the eastern slope of the Continental Divide at about 13,000 feet elevation. In contrast to the high level of the headwaters, the mouth of the river is about 400 feet above mean sea level.

The land features of the Basin likewise vary between great extremes. Along the western bounds some of the highest mountains in the United States may be found, while vast stretches of flat terrain lie in the Central Great Plains region. With the exception of the mountain slopes and areas adjacent to the streams, the Basin was originally devoid of tree growths. The land lying west of the Missouri River is known as the short grass country and that east of the river as the long grass country.

Climate - The area west of the 98th meridian has a semiarid climate with a yearly rainfall varying over the region from 8 to 18 inches. The area east of the 98th meridian is much more humid and receives an annual rainfall varying from 18 to 50 inches. Temperatures within the Basin are extremely variable, caused both by differences in elevation and differences in latitude. The mean annual temperature experienced in the mountainous areas of the Upper Missouri Basin is approximately 32° F., while that near the mouth of the Missouri is approximately 56° F. The growing season varies from a few weeks to six months.

Geology - The Rocky Mountain Uplift, the great glaciated and unglaciated Missouri Plateau, and the great plains of the Basin, generally characterize the geological history of the Basin. Geological oddities such as the Black Hills Uplift of western South Dakota and eastern Wyoming, the grotesquely eroded areas known as the Badlands of North and South Dakota, the great formations of windblown sand forming the Sand Hills Region of Nebraska, and such phenomena of nature as those in Yellowstone National Park, are found in the Basin.

Geological features of the Basin which tend to increase the hazards of pollution in underground waters are the occurrence of shallow subsurface aquifers subject to brine pollution from oil bearing formations in western Kansas, the unconsolidated gravel formation of North Dakota through which pollution can travel long distances, and the limestone of Missouri in which pollution may be carried through crevices for great distances to aquifers supplying water for domestic and municipal use.

Natural Resources - The natural resources of the Basin are numerous, the greatest in value being its soils and waters. Its mineral wealth includes gold, silver, lead, coal, oil, and many of the rare metals. The water resources are sufficiently limited in the Basin so that it is necessary to conserve and control them in order to obtain their potential usefulness. Both surface and ground waters are in general highly mineralized, ground waters in particular to such an extent in western South Dakota and Western North Dakota that their use is almost prohibitive.

Most streams tributary to the Missouri River are swift-flowing and carry prodigious amounts of silt into the main stem. Most of this silt is picked up after the streams leave the mountainous section of the Basin. The deep fine soils which cover most of the area, excluding the mountainous regions, are easily affected by the erosive action of water and wind.

Economic Development

The development of the Missouri Drainage Basin began at the extreme lower end and spread westward. For many years the principal commerce was that of fur trading, with the waterways forming the principal arteries of transportation. As the population of the nation increased there was a general tendency to seek new lands farther west. This process was greatly speeded by events such as the discovery of gold in California and in the Rocky Mountain regions. It was greatly implemented by the location of the railroad systems which were traversing the Basin from east to west. Such points as Council Bluffs, Iowa, St. Joseph and Kansas City, Mo., became great centers from which immigrants cast off to find land or other opportunities for better livelihood.

Following the Civil War there was a tremendous influx of population into the Basin. The trapper was no longer the backbone of the economy; agriculture rapidly replaced the fur trade. The National Homestead Act, placed in effect following the Civil War, made it relatively easy for pioneers to acquire land. Railroads stretched across the Basin in many directions. Towns were established and those in favored locations began to increase rapidly in population and became processing centers for products of the agricultural region. Population increases in the States continued until about 1920 and agriculture remained the principal economic factor of support. After 1920 the population became stabilized with comparatively small gains registered between the years 1920 and 1930. During the period from 1930 to 1940 a severe drought greatly affected the population dependent upon agriculture as a means of livelihood. There was considerable emigration during this period to other sections of the United States. Many rural areas within the Basin were depopulated with the inhabitants moving to the larger cities and towns. By 1940 most of the States had registered a decrease in total population with the most drastic reduction evident in rural populations.

Population trends between the years 1940 and 1950 indicate that several of the purely agricultural States have again lost population. It is also apparent that while rural populations have generally stabilized, there has been a considerable increase in urban population. It is of note that cities of more than 2,500 people continue to grow and expand in local importance. It is apparent that there is a gradual shift of population from agriculture to industry throughout the Basin. Improved farming methods make it possible for one man to produce a great deal more now than ever before. Industry, noting the savings to be had by establishing their processing plants near the source of raw material, is moving westward into the Basin. Food processing plants in ever increasing numbers have been constructed in the last 50 years.

The vastness of the region presupposes that there will be a variety of natural resources which may have a profound effect on the entire nation. In the order of importance, land and water rate highest. In addition to these, vast quantities of coal, oil, timber, and building materials are available to draw upon.

Since more than two-thirds of the area lies in a semiarid climate, water is its life blood. Water irrigates the land, serves the population for domestic and industrial purposes, and produces hydroelectric power. Because of its extreme limitations in quantity, a very high value has been placed upon it. As the competition for water increases it becomes more and more important that the water resources be carefully evaluated and properly protected to prevent wastage.

The meat packing industry leads all others in value, with the beet sugar and dairy industries following closely. The production and processing of petroleum is the leading industry dependent upon mineral resources, and is followed by those allied industries producing building materials and those connected with the mining and smelting of precious metals. Should the economy of the Nation demand it, it is probable that the synthesizing to liquid fuels of the vast coal and oil shale resources found in the northwestern section of the Basin may become a great new industry of extreme importance.

In regard to other future development possibilities, it may be expected that the industrial potentiality will be realized to a greater extent, partly because of the demands placed on industry by the National Defense Program and partially because of the economy of such a move to industry. In addition, a program is now being embarked upon by the Missouri Basin States and the Federal Government to conserve and control the waters and lands of the Missouri Basin. Such a program will permit greater production of agricultural materials; it will help to stabilize the economy and promises to bring about an increase in population necessary to support an increased agricultural and industrial economy.

The problem of stream pollution is closely tied into the general economic development of the Basin. Pollution problems become more acute as the urban populations increase and as industry expands in both kinds and value. Demands for water of high quality are becoming greater and greater.

USES OF WATER RESOURCES

For the purpose of discussing the uses of the water resources, the Missouri Basin is divided into two sections: that east of the 98th meridian which is a more humid area, and that west of the 98th meridian which is the semiarid region.

Uses of water west of the 98th meridian are extensive and include domestic and municipal water supply, irrigation, development of hydroelectric power, livestock watering, the propagation and support of fish and wildlife, recreation, and for cooling and processing at industrial installations. East of the 98th meridian the waters are used principally for sources of domestic and municipal supplies, to meet demands by industry for water for processing and cooling, for carrying industrial and domestic wastes, for navigation, for game and commercial fishing, for recreation, for a limited amount of livestock watering, and to support wildlife. In terms of volume of water, west of the 98th meridian irrigation and power demands exceed other uses, while east of the 98th meridian demands for industrial, municipal and navigation purposes are greatest.

West of the 98th meridian there are critical shortages of water. For example, in the South Platte Basin a combination of industrial development, a large urban population, and a tremendous irrigation demand have exceeded the volume of water available, and keen competition for such water as is available is very much in evidence. Other sections west of the 98th meridian, where water volume is seldom sufficient to meet all demands, include those drained by the Cheyenne and Belle Fourche Rivers in eastern Wyoming and central South Dakota, in the North Platte River below Casper, Wyo., and along the upper section of the Lower Platte. Eastern Colorado, southern Nebraska, and northwestern Kansas place a considerable value on the available water resources. There are numerous areas in the States of Wyoming, South Dakota, North Dakota, Montana, and Colorado where local conditions are such that the very existence of the inhabitants and livestock depend on the meager water supplies available from surface runoff. It is in these areas where major efforts have been made to conserve and reclaim waters for multiple-purpose benefits.

East of the 98th meridian water resources are seldom critical except in times of extreme low flows. However, during these periods the situation has in the past become precarious because of the dependency placed on water resources by the large municipalities and industrial installations which support more than one-half of the Basin's population. Stream regulation and low flow augmentation through the Basin Development Program holds promise for alleviation of this condition at numerous locations.

In order to indicate the importance of the several major uses of surface water in the Missouri River Drainage Basin, the following current and near future demands are cited: 209 municipal water supplies serving 2,300,000 persons; irrigation of 12 million acres; in excess of one billion gallons daily for industrial cooling and processing purposes; removal and ultimate disposal of the liquid wastes of 979 municipal and 188 industrial outlets; water to supply from 20,000 to 30,000 second-feet during the navigation season in the main stem of the Missouri River from Sioux City to its mouth for navigation; enough for the generation of 13 billion kilowatt-hours of electricity annually; 15 million man days annually of recreational and game fishing time, and the needs of many millions of farm animals. These needs are for the most part current and do not reflect ultimate requirements, i.e., future hydroelectric power.

POLLUTION CONTRIBUTED TO WATER RESOURCES

Table A indicates that there are 979 municipalities, institutions and sanitary district sewage outlets in the Missouri River Basin. The table also indicates that sewers serve 3,530,200 persons to which may be added 1,325,400 population equivalent units of industrial waste discharging to municipal sewers (footnote to table A) for a total of 4,855,600 population equivalents tributary to municipal sewers. The amount of municipal pollution discharged to the streams of the Basin is estimated at a population equivalent of 3,271,200. The difference, 1,584,400 population equivalents, between the contributed waste and discharged waste represents that removed by treatment. This represents a removal of about 33 percent of the biochemical oxygen demand of the raw wastes carried in municipal sewers.

Table B indicates that there are 110 industrial outlets contributing 8,486,500 population equivalents to the watercourses of the Basin. In addition to these sources there are 42 more which contribute organic waste, the population equivalents of which have not been determined. Most of the plants contributing organic wastes are associated with the processing of food and kindred products, such as sugar refineries, meat packing plants and creameries. Many of the plants indicated as producing both organic and inorganic wastes (see footnotes to table B) are those connected with the petroleum production and processing industry. Organic wastes for this industry consist of wasted oil and phenols, while caustic material and brines make up the inorganic wastes. Other sources of inorganic waste are mining operation and the manufacture of certain chemicals. The wastes from the mines consist of acid drainage, rock flour, coal dust, etc. Wastes such as cyanides are associated with the mining and separating of gold from other ores.

A comparison of the wastes discharged by industrial and municipal outlets reveals that the population equivalent of the industrial waste is approximately two and one-half times that of municipal waste.

Silt is an important aspect of the over-all problem of pollution in the Missouri Basin. In the main stem below the Yellowstone, and in the lower reaches of several tributaries, silt more adversely influences certain water uses, as fishing and recreation, than does municipal and industrial pollution. Silt removal is an important although relatively uncomplicated aspect of municipal and industrial water treatment. As silt control is more logically a function of agricultural and other interests, discussions of this report are largely limited to recognition of the problem. Reservoir construction, watershed management, reforestation, soil conservation and related aspects of the Missouri Basin Development Plan may ultimately do much to alleviate the problem of silt pollution in the Basin.

Table A - Sources of pollution - Municipal

Municipalities*	Sources of pollution (In number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (In terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	953	3,462,900***	3,271,200
Having population data available (Data on pollution load to watercourse incomplete or not available)	26****	67,300	Not applicable
Total	979	3,530,200	- - - -

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers, or other population centers; sanitary sewage wastes discharged by industry directly to watercourse.

** Includes industrial wastes discharged into municipal sewerage systems.

*** Data do not include industrial waste of 1,325,400 population equivalent discharging to municipal sewers.

**** Includes four municipalities having collection systems for which "population served" is unknown.

Table B - Sources of pollution - Industrial*

Industries	Sources of pollution (In number of plants)	Amount of pollution discharged to watercourse (In terms of equivalent number of people)
Producing organic wastes	110**	8,510,600
Producing organic wastes	42***	Undetermined
Producing inorganic wastes	71****	Not applicable
Producing wastes of undetermined type	1	Undetermined
Total	188*****	- - - -

* Industries having separate outlets and discharging wastes directly to watercourse.

** Includes 16 plants also producing inorganic wastes.

*** Includes 20 plants also producing inorganic wastes.

**** One plant operated intermittently.

***** Total adjusted to correct for duplication noted in footnotes marked thus *** and **.

DAMAGES TO WATER RESOURCES FROM POLLUTION

Water pollution, from the standpoint of stream sanitation, is caused by those substances that produce detrimental changes in the organic, chemical, biological or physical characteristics of receiving bodies of water. A study of court cases by Professor Don E. Bloodgood 1/ revealed some 28 conditions and materials that have been recognized legally as causing pollution of streams. It is of interest to peruse these:

> "Noxious and noisome slime on banks and bed of a stream; wastes that cause foul odors; odors that are carried two miles on either side of a stream; deposition of offal, filth and noisome substances; discharges of chemicals or deleterious substances that kill fish, create noxious vapors or provide breeding places for large numbers of flies or insects; sewage discharges into water so that cattle will not drink it; milky distillery wastes; wastes that settle and decompose into sludge; small quantities of polluting substances; oil discharges changing taste of water; dyes causing stream discoloration; discharges of soap, soda ash, soda salts, blue vitriol, lead, arsenic, poisonous mining wastes, caustic soda, petroleum, and methyl alcohol; wastes that cause pipe corrosion or skin irritation; salt water or mine-wash discharges that run in water supplies; and disposal of wastes that contaminate ground or surface water supplies."

Silt has recently been declared pollution by a Maryland court. Numerous other situations will, no doubt, be recognized as pollution.

The impairment of water quality by pollution represents damages that may include both tangible and intangible values. In many instances, the intangible will far exceed tangible values. It is not possible to place a monetary value on public welfare and well-being and, in some cases, on public health, although these factors assume tremendous importance in our daily lives. The complexity of these relationships is well known; an illustration is the possible transmission of disease by the consumption of raw vegetables and fruits irrigated with sewage polluted waters.

1/ Don E. Bloodgood, Professor of Sanitary Engineering, Purdue University, Lafayette, Ind., "Engineering News-Record," December 9, 1948.

The discharge of untreated sewage to watercourses of the Missouri River Basin undeniably creates local public health hazards and nuisances. Possible damages that may be suffered are related directly to the uses of the water resources. In addition the presence of clean waters in a bright sparkling stream does much to enhance psychological well-being of those who come in contact with it.

Pollution has a definite detrimental effect on sources of public water supplies. W. H. Wisely 2/ estimates that the abatement of pollution of a water supply may reduce municipal water plant treatment costs from $1.00 to $8.00 per million gallons and would materially lessen the constant menace from pathogenic organisms. Many water treatment plants located on the Missouri, Kansas, and other rivers of the Basin treat water with high coliform counts, and in numerous instances resort to complex procedures to assure production of a safe water. Water supplies in several instances have been damaged beyond treatment possibilities by pollution. Below Billings, Mont., on the Yellowstone River, municipal and industrial pollution prevented the continued use of this water by individuals who formerly only chlorinated the supply to provide a potable water. Water supply sources have been damaged by other pollution factors. Saline brine from oil fields forced Russell, Kan., to seek another source for its public supply. Settling of silt at the Holton, Kan., impounding reservoir is threatening to deplete its capacity and may necessitate construction of a pipeline several miles to the Missouri River. In general, prevention of ground water supply contamination by proper brine and oil disposal is a problem of oil field areas.

Water used by industry must meet quality standards dependent upon the processes involved. Boiler water must be soft and noncorrosive; the canning of foods requires a high quality water with a minimum of dissolved solids; bottling works need a water free of taste and odors and the absence of organisms which might develop aftergrowths.

Industrial water treatment plants located in the Missouri River Basin now require large expenditures of money annually to correct corrosiveness, hardness, and other objectionable features of polluted

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2/ W. H. Wisely, Executive Secretary-Editor, Federation of Sewage Works Association, "It Takes Money to do the Job--But It's Worth It."

waters. Polluted waters encourage the growth of slimes that interfere with cooling water operations. In addition, replacement of equipment damaged by chemical or abrasive characteristics of waters costs additional sums.

One of the more important potential hazards of sewage pollution is the use of contaminated waters for irrigation. The application of sewage-contaminated waters to truck crops that are generally consumed raw may distribute pathogenic organisms to wide segments of the population. An outbreak of disease traceable to the use of polluted irrigation waters would cause irreparable damage to the farmers raising these crops. Acreages devoted to truck crops represent a small but important segment of irrigated farming.

Damage to fish and wildlife caused by pollution is an important consideration. The history of this Basin reveals that fish abounded in many of the streams. Although fish life in the larger rivers has always been restricted because of the large quantities of silt carried, the smaller streams originally teemed with game fish. Pollution of various types has encroached upon this stream use until highly prized fishing areas remain only in the headwaters of these streams. Fish kills have been reported recently in Big Creek in central Kansas as a result of municipal and industrial pollution, and in the Nemaha River in southeastern Nebraska because of oil wastes. Organic pollution that depletes the dissolved oxygen essential to fish life, toxic substances, excessive silt from mine tailings and inadequate erosion control, acid mine drainage, all are detrimental to fish propagation. Oil and related compounds taint the flesh of fish making them unpalatable and unmarketable, which represents a considerable economic loss.

The Fish and Wildlife Service, Department of the Interior, reports that pollution from domestic and industrial waste has had a moderately damaging effect on fish life in the Yellowstone River from Laurel to Custer, Mont.; and has had a destructive effect on fish life in the Milk River from Chinook to Glasgow, Mont. In Wyoming fish life is reported to have been destroyed in the North Platte River from Casper to Guernsey Reservoir by a combination of domestic and industrial waste. Fishery values have been destroyed by pollution in the South Platte River below Denver, Colo., and its tributary streams including the Cache la Poudre River below Ft. Collins, Colo. and the Big Thompson River below Loveland, Colo. In South Dakota severe damage to fishing from industrial waste has been experienced in the Belle

Fourche River below Belle Fourche, S. Dak. In Kansas, pollution reportedly has destroyed the fishing value of the Kansas River from Junction City to Lawrence, Kan., and has caused severe damage to fishery values in the Smoky Hill and Saline Rivers below Wilson and Russell, Kan., respectively. In Iowa severe damage to fish life in the Floyd River is reported, and in Missouri, fishing is considered to be moderately damaged below Kansas City on the main stem of the Missouri River for a distance of 30 miles.

The lack of suitable recreational areas over a large portion of the Missouri Basin enhances the importance of this phase of stream use. Bathing in sewage contaminated streams is inimical to public health. In many instances pollution has caused prohibition of various river reaches for recreation. Damages to the health and well-being of the population in these areas must be appreciable.

Numerous other damages may be cited. Septic stream conditions create foul gases such as hydrogen sulphide, which tarnishes metals, dulls paint, and is an odor nuisance. Property values decrease in the vicinity of offensive streams, causing one of the great economic losses from stream pollution.

BENEFITS RESULTING FROM POLLUTION PREVENTION AND ABATEMENT

The abatement of pollution in the Missouri Basin will (a) provide a source of domestic water supply free from excessive bacteria and organic material, (b) allow the waters of the Basin to be used extensively for recreational purposes with a minimum of hazard to the public health, (c) provide clean water necessary for the propagation of fish life, waterfowl, and aquatic fur animals and thereby greatly expand the income of the Basin for tourists, hunters, trappers and fishermen interested in the attractions thus provided, (d) remove or substantially decrease the probability that enteric diseases will be incurred by the use of vegetables and fruit grown on land irrigated by sewage-ladened water, (e) result in the removal of mineral or other inorganic contaminants such as oil field brines, acid mine wastes, and tailings from mining operations which now cause considerable loss to downstream water users, and (f) result in higher quality water for industrial use.

The benefits resulting from water pollution control are many and widespread. Tangible benefits to be realized may be readily estimated. Reduced operating costs at municipal and industrial water treatment plants will be experienced. Fish and wildlife conservation and recreational development are improved. Fish and wildlife yields are produced much more cheaply in clean water than in dirty water. Fishery values will appreciate as reflected by game and commercial species caught, and by income from the sale of a greater number of fishing permits, not to mention expenditures related to the sport by ardent anglers. Reduction in travel distances to recreation areas may represent sizable savings. The use of streams for livestock watering will be enhanced. Property values will rise along streams where pollution has been abated.

Intangible values, although difficult to evaluate, may even overshadow those benefits readily determined on a monetary base. Protection to public health, nuisance prevention, recreation, and the enhancement of the general welfare are all factors of vital concern to the well-being of the inhabitants of the Basin. The public health is guarded as the result of water supply protection and improvement of the bacterial quality of irrigation water that may be dispersed on crops consumed uncooked. Nuisances are prevented and the general welfare of the public is enhanced. The improvement of sanitary environment will bring about an improvement in general public health, which in turn results in greater enjoyment of living, increased longevity, and increased production per capita.

Tangible monetary benefits from pollution control resulting from flow regulation may be evaluated in numerous instances. Generally a minimum of primary treatment is required by the State Water Pollution Control Agency, unless other downstream water uses or the normal mean minimum monthly flows are such that a higher degree of treatment is necessary. The relationship of sewage treatment and minimum sustained stream flows should produce stream conditions which will prevent public health hazards and will sustain a balanced aquatic life. It should be possible to plan for regulated minimum flows in the Missouri River Basin, since many of the streams will be regulated under the proposed Missouri River Basin Development Program. Progress toward this objective is apparent. It is important however that benefits from releases for sewage dilution purposes be recognized and weighed carefully against benefits from competitive uses of water.

POLLUTION PREVENTION MEASURES IN EFFECT

Table C indicates that 67 percent of the municipalities having sewer systems are also equipped with sewage treatment facilities. In terms of population served by such treatment facilities, table C shows that 53 percent of the domestic population is thus provided treatment. This latter figure might be broken down further to indicate that 24 percent of the population is served by primary treatment and 29 percent by secondary treatment works.

Table D indicates that the food and petroleum industries lead in numbers of sources of waste. The picture of waste treatment in the industrial field is illustrated by the fact that 30 percent of those industries listed do have some type of treatment facilities. It is noted however that only 10 percent of the industries are known to have facilities capable of providing adequate treatment. This is indicated in table G.

Table E reveals that about 52 percent of the municipal treatment plants for which data are available are provided with adequate capacities to meet the demands of a stream pollution abatement program; however, it may be noted from table G that only 18 percent of the population connected to sewer systems for which treatment requirements have been determined is served by these plants. Table E further indicates that the operation of the plants is generally more satisfactory than the design. The same thing is true with respect to industrial waste treatment facilities.

Table F indicates that in the four years 1946 through 1949, 59 municipal sewage treatment plants and 11 industrial waste treatment works were constructed in the Missouri Basin. The plants were constructed largely by the smaller municipalities and industrial plants as indicated by the design capacities of the various treatment works.

Table C - Existing treatment facilities - Municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	262	273	862,500
Secondary	394	416	1,013,000
No treatment	323	- - - -	1,654,700

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

Table D - Existing treatment facilities - Industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products ---------	113	20	72	21
Paper and allied products ---------	1	0	1	0
Chemical and allied prod. ------	7	3	3	1
Products of petroleum and coal ----	33	24	5	4
Rubber products --	1	1	0	0
Primary metal --- industries--------	13	4	7	2
Miscellaneous ----	9	4	3	2
Mine drainage ----	1	0	1	0
Other mining industries ------------	10	1	6	3
Total	188	57	98	33

* Industries having separate outlets and discharging wastes directly to watercourse.

Table E - Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satis-* factory	Unsatis-factory	Unde-termined	Satis-factory	Unsatis-factory	Unde-termined
Municipal	689	383	271	35	482	134	73
Industrial	57	22	13	22	27	2	28

* Existing treatment facilities are generally considered satisfactory if the design capacity of the units is adequate. Additional units are needed in some cases to provide higher degree of treatment. Table G reflects these additional needs.

Table F - Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (In terms of equivalent number of people)
1946	4	3,830	0	- - - -
1947	12	21,280	4	3,000*
1948	15	24,175	3	4,370
1949	28	90,075	4	28,700

* Population equivalent of 3 plants unknown.

POLLUTION PREVENTION MEASURES REQUIRED

Tables C and G indicate that an increase of approximately 50 percent in the number of treatment facilities will be necessary to bring about an adequate stream pollution abatement program in the Missouri River Basin. In addition, approximately 40 percent of the existing facilities must either have entirely new plants, be enlarged or replaced. Eight percent of the municipal sources and 45 percent of the industrial sources of pollution are unclassified as to needs.

Table H indicates that 26 percent of the known municipal requirements and 11 percent of the known industrial requirements as indicated in table G have been brought to some stage of activation. A listing of the individual project needs, together with its action status, may be found in Table I in the appropriate Sub-Basin section of this report.

It appears that improved legislation, a necessary prologue to a construction program, must be brought about within the Basin before lasting gains against the inroads of pollution can be expected. A background of State legislation which encourages pollution abatement is essential. An abatement program requires legislation authorizing effective control activities and funds for personnel to operate such a program.

Specific weaknesses in the legislation of the States of the Missouri Basin vary, however there are some that are common to all. There is no provision in most legislation permitting State water pollution control agencies to enter into compacts with other States, interstate groups or the Federal Government. Only Iowa, Kansas, Minnesota, and South Dakota have legislation relating pollution to all legitimate water uses. Missouri and Nebraska have virtually no legislative provisions for control and abatement of pollution. In the remaining States only pollution influencing public health is subject to abatement proceedings. Colorado excludes industry from control measures. No water pollution control agency in the Basin has statutory authority for the development of a comprehensive program for the control and abatement of water pollution. Only in Colorado, Minnesota, and South Dakota are the Water Pollution Control Agencies authorized to establish standards of water quality. Only in Minnesota and South Dakota are the Water Pollution Control Agencies authorized to classify waters as to use. There is generally a lack of legislation which would establish minimum standards of operation of treatment works. This type of legislation is important as an instrument for obtaining better use of treatment works once they are constructed. In Missouri and Kansas financial limitations are so restrictive as to prohibit much needed water treatment works construction.

Legislation should be broadened to insure abatement of pollution when and where it may be deleterious to legitimate water uses and the public interest.

As the Federal Water Pollution Control Act recognizes that pollution abatement is a State prerogative, improved uniform legislation is needed in several States to implement the program necessary to carry out this responsibility. The influence of a strong body of law is a powerful one, even though the enforcement machinery created by it may seldom be called upon to function.

It is of equal importance that the general public be made aware of the needs for pollution abatement. Such public understanding is necessary for the enforcement of laws and for the financing of abatement works. Promotional work must be supported by studies, investigations and hearings.

An accurate estimate of the total cost of pollution abatement in the Missouri River Basin would require numerous data which are not now available, such as (1) the degree of required treatment based upon stream characteristics and most beneficial downstream water uses, (2) additional detailed data on local sewage works systems, and (3) research on methods and costs of treating certain industrial wastes for which there are at present no known suitable methods.

On the basis of available information it is estimated that the initial cost of required municipal waste treatment facilities will be $115,000,000. This estimate includes the cost of treatment of industrial wastes now discharged to municipal sewerage systems and those which are amenable to treatment in municipal treatment plants. The initial cost of required industrial waste treatment is estimated to be $34,000,000 and includes only those costs of treating industrial wastes now being discharged directly to streams where there is little likelihood of their being treated in municipal treatment plants. The total initial cost of required municipal and industrial waste treatment facilities is estimated at $149,000,000.

Recognizing that these expenditures will take place over a number of years, the estimated costs will be increased due to added factors. These include additional annual obsolescence and rehabilitation requirements, needs of communities installing new sewer systems, normal population increases and industrial expansion, as well as allowance for presently undetermined needs.

In preparing the above estimates costs for the smaller municipalities were estimated by applying per capita cost figures derived in cooperation with General Services Administration from the analysis of sewage treatment plant construction costs incurred in the Basin during the 1946-1949 period. Estimates of cost for the larger cities were obtained from consulting engineers' reports, and from city engineering department estimates as prepared for the 1946 postwar planning program. A factor, representing a 42 percent increase, was applied to the latter figures to conform with the average increase of construction costs during the period 1946 to 1950. The total cost estimates include a 15 percent addition to cover the expense of planning, legal service, financing, land acquisition, and related items.

The cost of industrial waste treatment was estimated on the basis of the type of waste, its production characteristics (such as whether it is seasonal, constant or varying in amounts), the location of the industry with regard to availability of dilution water, availability of land for lagooning or evaporating wastes; and the complexity of treatment involved. Individual sub-basin estimates range from $2.00 per capita for the population equivalent of certain industrial wastes under favored conditions to $8.00 per capita under less favorable conditions. It is believed that these estimates are in most instances quite conservative.

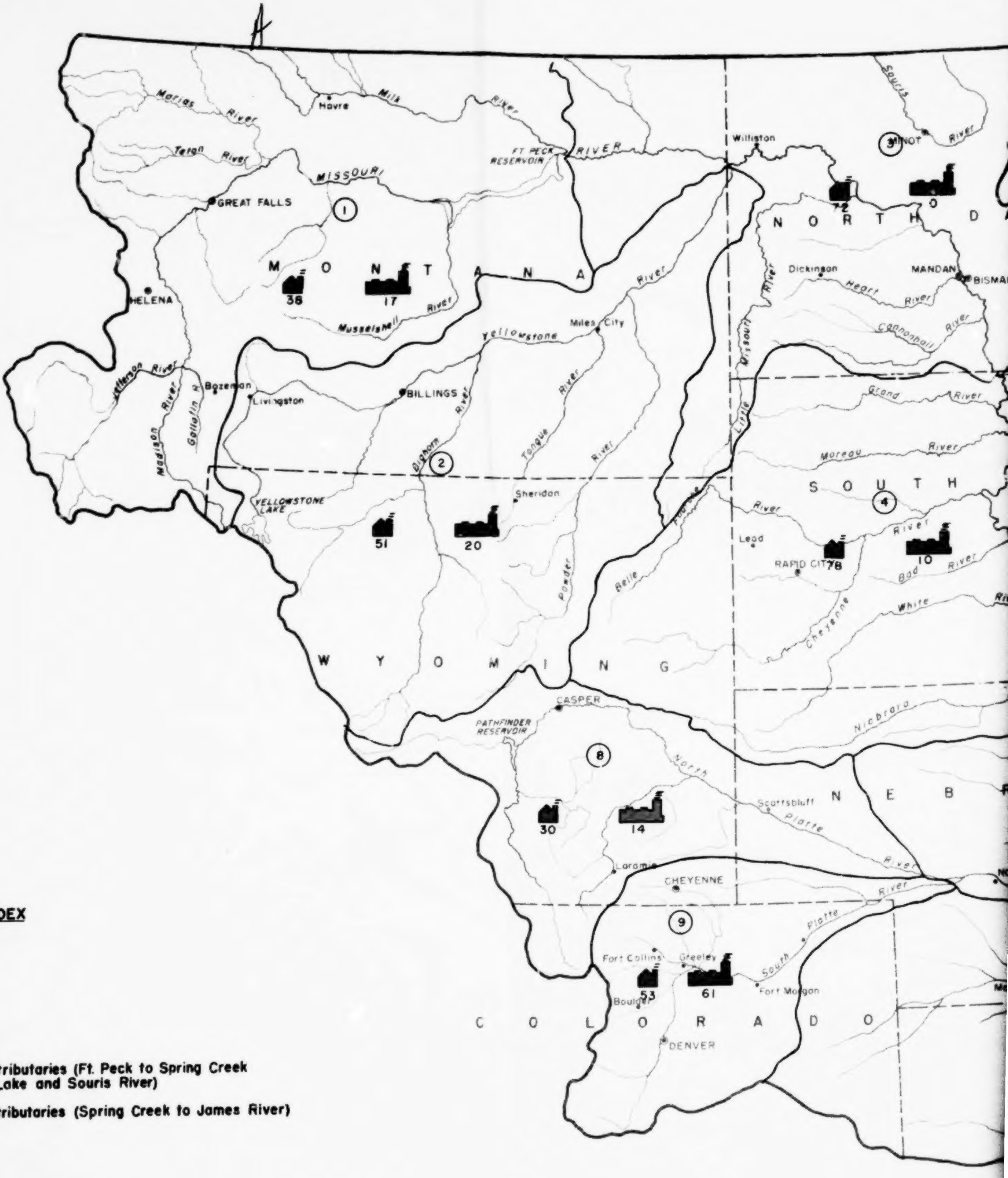
Table G - Requirements for municipal and industrial waste treatment plants

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	356*	1,059,900	70
Enlargement or additions to existing plant	181	1,174,500	13
Replace existing plant	56	74,400	1
No project required	338	522,900	19
Undetermined	81	698,400	85

* Includes 33 existing facilities, which due to local conditions have been classified as needing new plants rather than replacements.

Table H - Status of treatment works project to abate pollution - July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	378	69
Abatement ordered	47	1
Plans under preparation	38	5
Final plans approved	32	2
Construction awaiting financing	1	0
Under construction	37	1
Status undetermined	60	7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MINOT
GREAT FALLS
HELENA
Musselshell River
Jefferson River
Madison River
Gallatin R.
Bozeman
Livingston
BILLINGS
Yellowstone River
Miles City
Bighorn River
Tongue River
Powder River
Little Missouri River
Dickinson
MANDAN
BISMA
Heart River
Cannonball River
Grand River
Moreau River
River
Lead
RAPID CITY
Bad River
White River
Cheyenne
Belle Fourche
YELLOWSTONE LAKE
Sheridan
CASPER
PATHFINDER RESERVOIR
North Platte River
Niobrara
Scottsbluff
Laramie
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Fort Collins
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South Platte River
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ASIN INDEX

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em and tributaries (Ft. Peck to Spring Creek
Devils Lake and Souris River)

em and tributaries (Spring Creek to James River)

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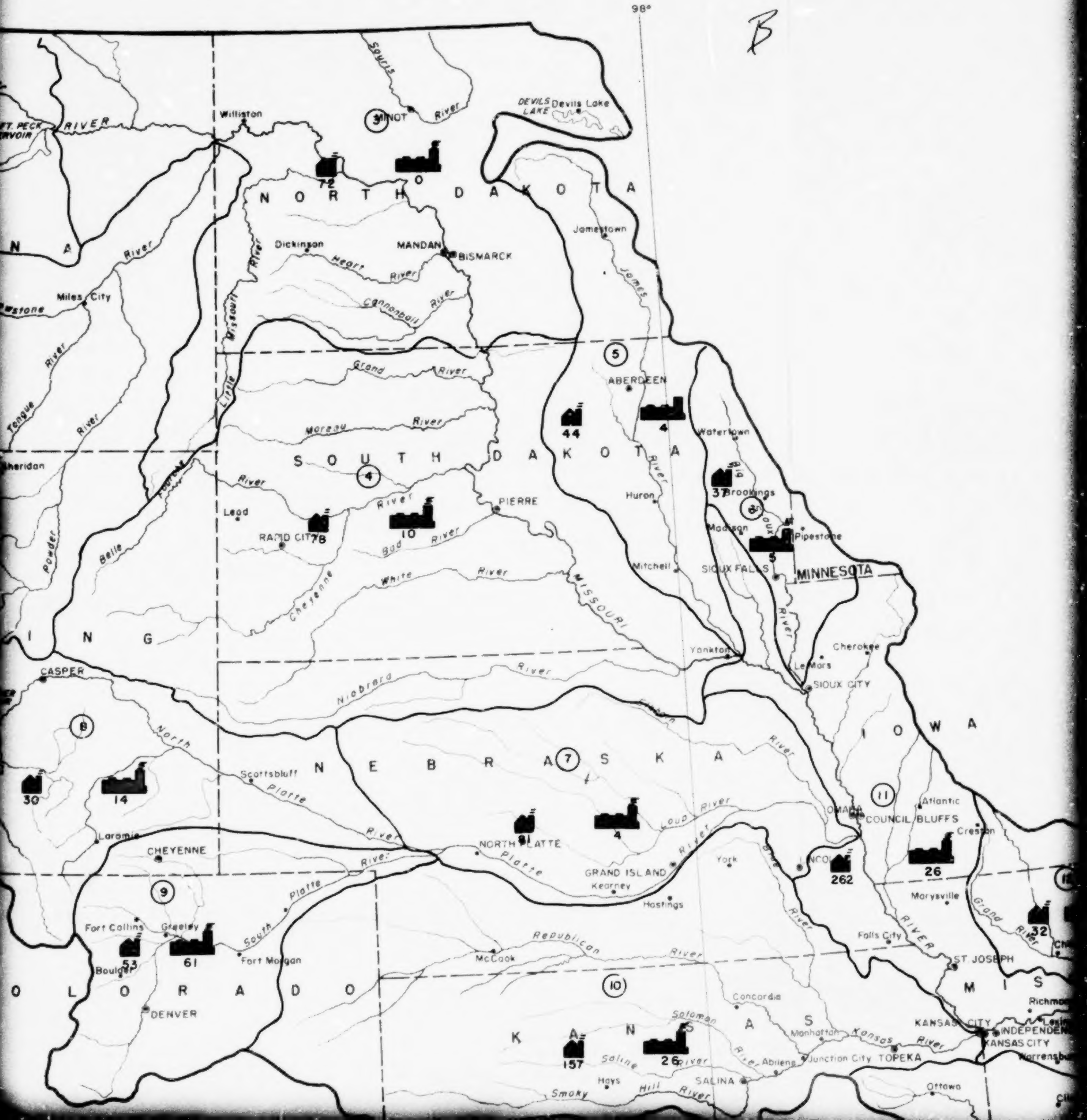
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Cannonball River
Missouri River
Little Missouri River
Miles City
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Tongue River
Powder River
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James River
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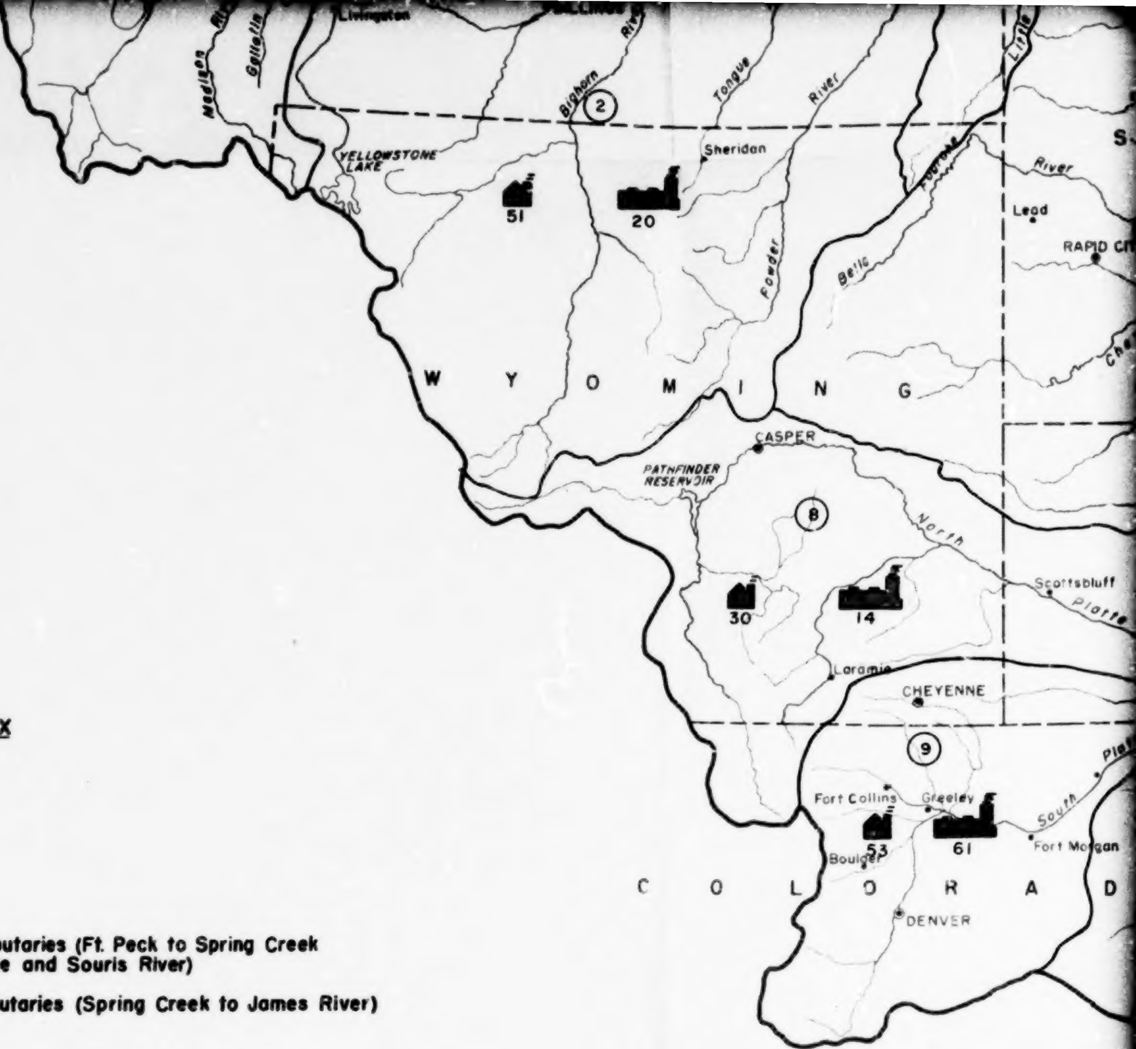
PIERRE
Bad River
Cheyenne River
Belle Fourche River
White River
MISSOURI
Watertown
Big Sioux River
37
⑥
Brookings
Huron
Madison
Pipestone
5
Mitchell
SIOUX FALLS
Yankton
Cherokee
Le Mars
SIOUX CITY
Niobrara River
Elkhorn River
CASPER
⑧
North Platte River
30
14
Scottsbluff
Laramie
CHEYENNE
⑦
81
4
Loup River
NORTH PLATTE
Platte River
GRAND ISLAND
Kearney
Hastings
York
Blue River
LINCOLN
262
OMAHA
⑪
Atlantic
COUNCIL BLUFFS
Creston
26
Marysville
Grand River
32
Falls City
RIVER
ST. JOSEPH
⑨
Fort Collins
Greeley
53
61
Boulder
South Platte River
Fort Morgan
DENVER
Republican River
McCook
⑩
Concordia
Solomon River
Manhattan
Kansas River
157
26
Saline River
Abilene
Junction City
TOPEKA
Hays
SALINA
Smoky Hill River
KANSAS CITY
INDEPENDENCE
KANSAS CITY
Warrensburg
Richmond
Lexington
Ottawa


Livingston
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Gallatin
Bighorn River
Tongue
River
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YELLOWSTONE LAKE
Sheridan
51
20
Powder
Belle
Fourche
River
Little
S
Lead
RAPID CI
W Y O M I N G
CASPER
PATHFINDER RESERVOIR
8
North
Platte
30
14
Laramie
Scottsbluff
CHEYENNE
9
Fort Collins
Greeley
53
61
South
Platte
Fort Morgan
Boulder
DENVER
C O L O R A D

SUB-BASIN INDEX

① Upper Missouri

② Yellowstone

③ Main stem and tributaries (Ft. Peck to Spring Creek including Devils Lake and Souris River)

④ Main stem and tributaries (Spring Creek to James River)

⑤ James

⑥ Big Sioux

⑦ Lower Platte

⑧ North Platte

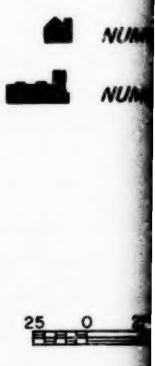
⑨ South Platte

⑩ Kansas

⑪ Main stem and minor tributaries (James to mouth)

⑫ Grand-Chariton

⑬ Osage-Gasconade


NUM
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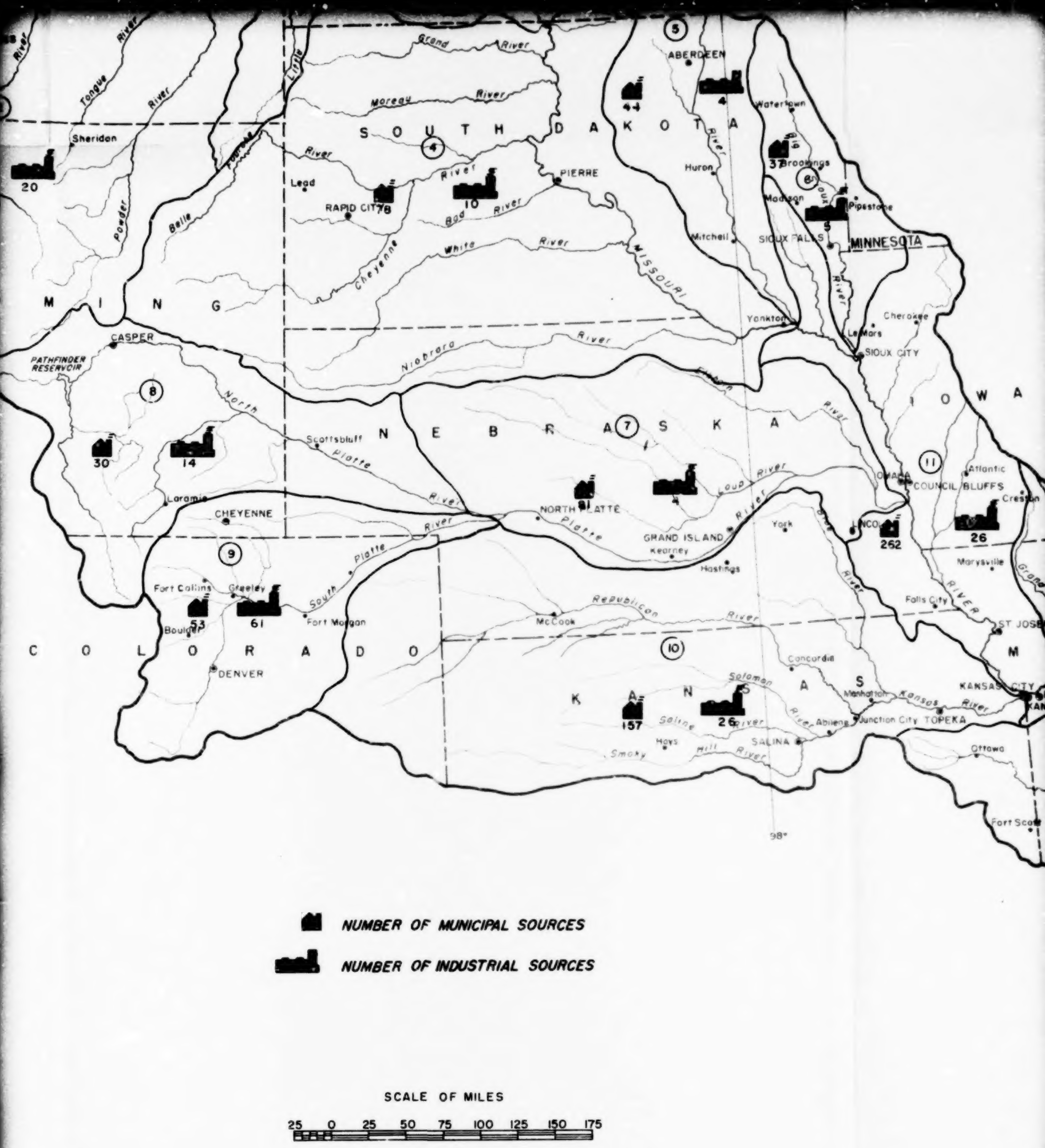
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KANSAS
COLORADO
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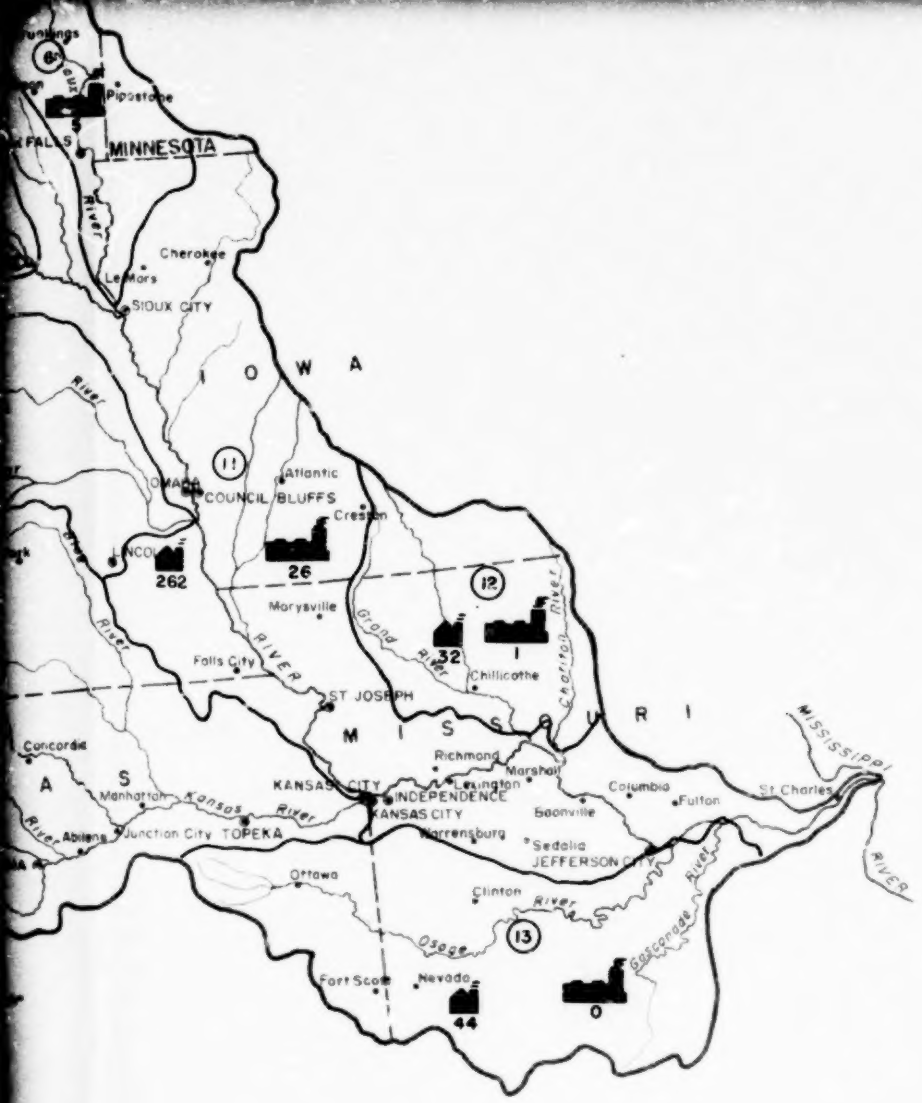
Watertown
Huron
Mitchell
Brookings
Madison
Pipestone
SIOUX FALLS
Yankton
Le Mars
Cherokee
SIOUX CITY
PIERRE
Lead
RAPID CITY
Sheridan
CASPER
PATHFINDER RESERVOIR
Laramie
CHEYENNE
Scottsbluff
NORTH PLATTE
GRAND ISLAND
Kearney
Hastings
York
LINCOLN
OMAHA
COUNCIL BLUFFS
Atlantic
Creston
Marysville
Falls City
ST JOSE
Fort Collins
Greeley
Boulder
DENVER
Fort Morgan
McCook
Concordia
Manhattan
Junction City
TOPEKA
Abilene
SALINA
Hays
KANSAS CITY
Ottawa
Fort Scott
Tongue River
Powder River
Belle Fourche
Little
Grand River
Moreau River
Cheyenne River
Bad River
White River
MISSOURI
Niobrara River
North Platte River
South Platte River
Platte River
Loup River
Elkhorn River
Big Sioux River
Republican River
Solomon River
Saline River
Smoky Hill River
Kansas River
Blue River
98°
20
44
4
37
5
78
10
30
14
81
4
262
26
53
61
157
26
NUMBER OF MUNICIPAL SOURCES
NUMBER OF INDUSTRIAL SOURCES
SCALE OF MILES
25
0
25
50
75
100
125
150
175

D


MINNESOTA
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Warrensburg
Sedalia
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Manhattan
Junction City
TOPEKA
Abilene
Concordia
Ottawa
Clinton
Fort Scott
Nevada
Grand River
Chariton River
Kansas River
Osage River
Gasconade River
MISSISSIPPI RIVER
11
12
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262
26
32
1
44
0

MISSOURI DRAINAGE BASIN
SOURCES OF POLLUTION

FEDERAL SECURITY AGENCY
Public Health Service
DIVISION OF WATER POLLUTION CONTROL

MAP NO. 1

942709 O - 51 (Face blank p. 40) No. 1

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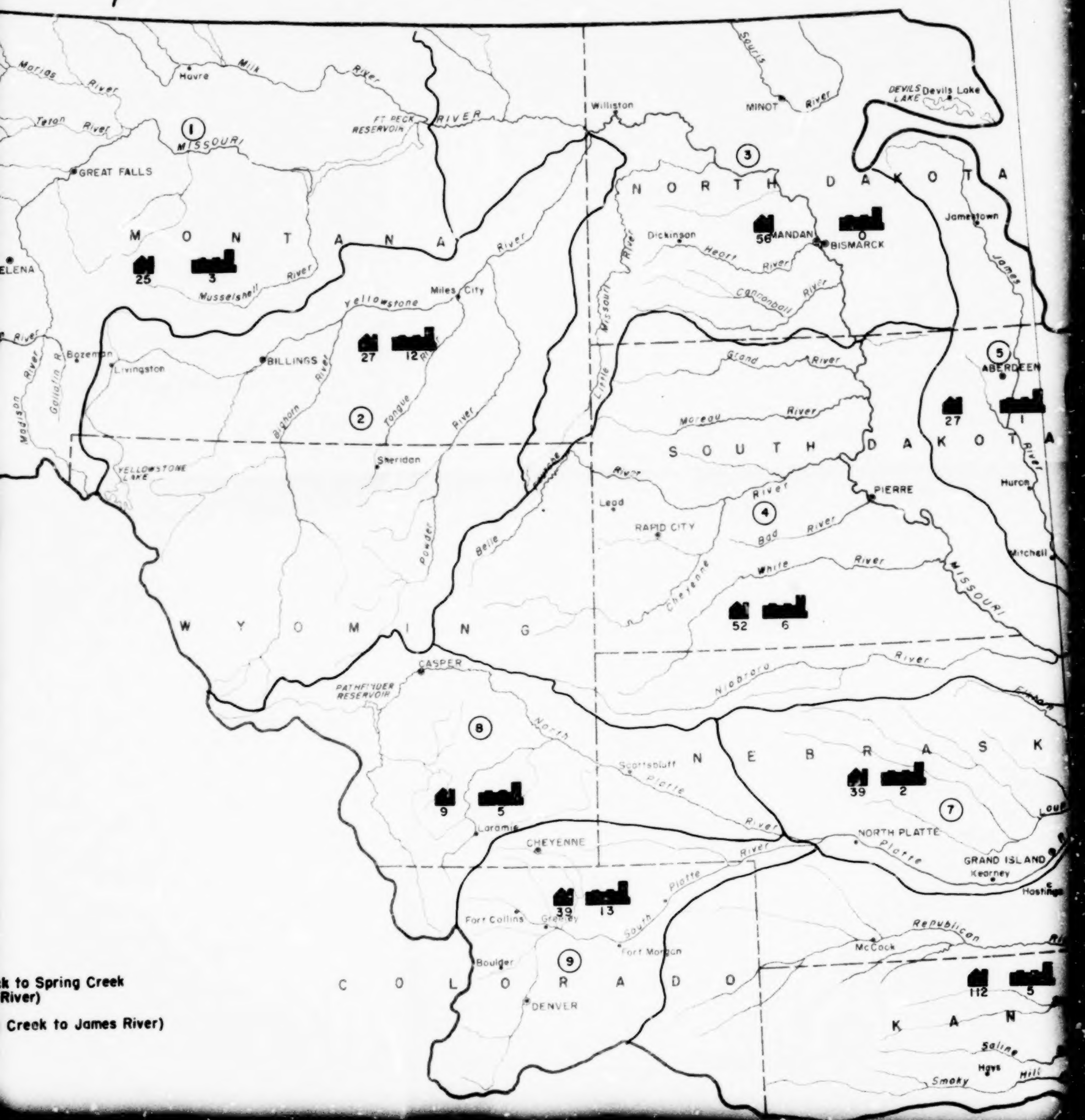
98°
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SOUTH DAKOTA
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NEBRASK
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① ② ③ ④ ⑤ ⑦ ⑧ ⑨
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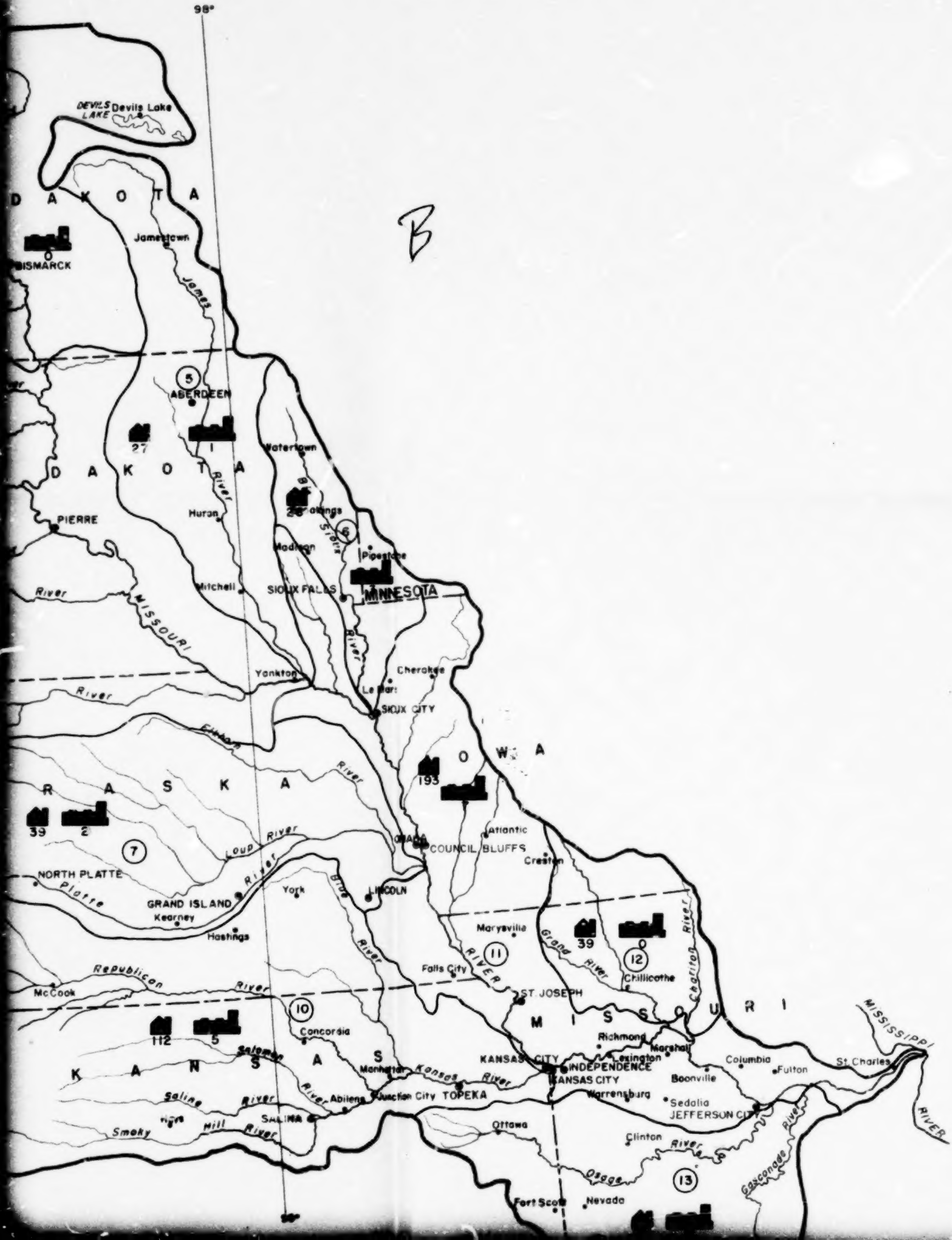
ELENA
Bozeman
Livingston
BILLINGS
Miles City
Sheridan
Williston
MINOT
Devils Lake
DEVILS LAKE
Jamestown
Dickinson
MANDAN
BISMARCK
ABERDEEN
Huron
Mitchell
PIERRE
Lead
RAPID CITY
CASPER
PATHFINDER RESERVOIR
Scottsbluff
Laramie
CHEYENNE
NORTH PLATTE
GRAND ISLAND
Kearney
Hastings
McCook
Fort Collins
Greeley
Fort Morgan
Boulder
DENVER
Hays
FT PECK RESERVOIR
YELLOWSTONE LAKE
Marias River
Milk River
Teton River
MISSOURI RIVER
Musselshell River
Yellowstone River
Bighorn River
Tongue River
Powder River
Madison River
Gallatin R.
Little Missouri River
Souris River
Heart River
Cannonball River
Grand River
Moreau River
James River
Belle Fourche River
Cheyenne River
Bad River
White River
Niobrara River
North Platte River
South Platte River
Platte
Republican
Saline
Smoky Hill
Loup
Elkhorn
k to Spring Creek
River)
Creek to James River)

B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Devils Lake
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BISMARCK
James
5
ABERDEEN
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1
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Watertown
River
Huron
28
Brookings
Big Sioux
6
Madison
Pipestone
PIERRE
Mitchell
SIOUX FALLS
MINNESOTA
River
MISSOURI
River
Yankton
Cherokee
Le Mars
River
SIOUX CITY
Elkhorn
River
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R A S K A
39
2
7
Loup River
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COUNCIL BLUFFS
Atlantic
Creston
NORTH PLATTE
Platte
River
GRAND ISLAND
Kearney
York
Blue
LINCOLN
Hastings
Maryville
Grand
River
39
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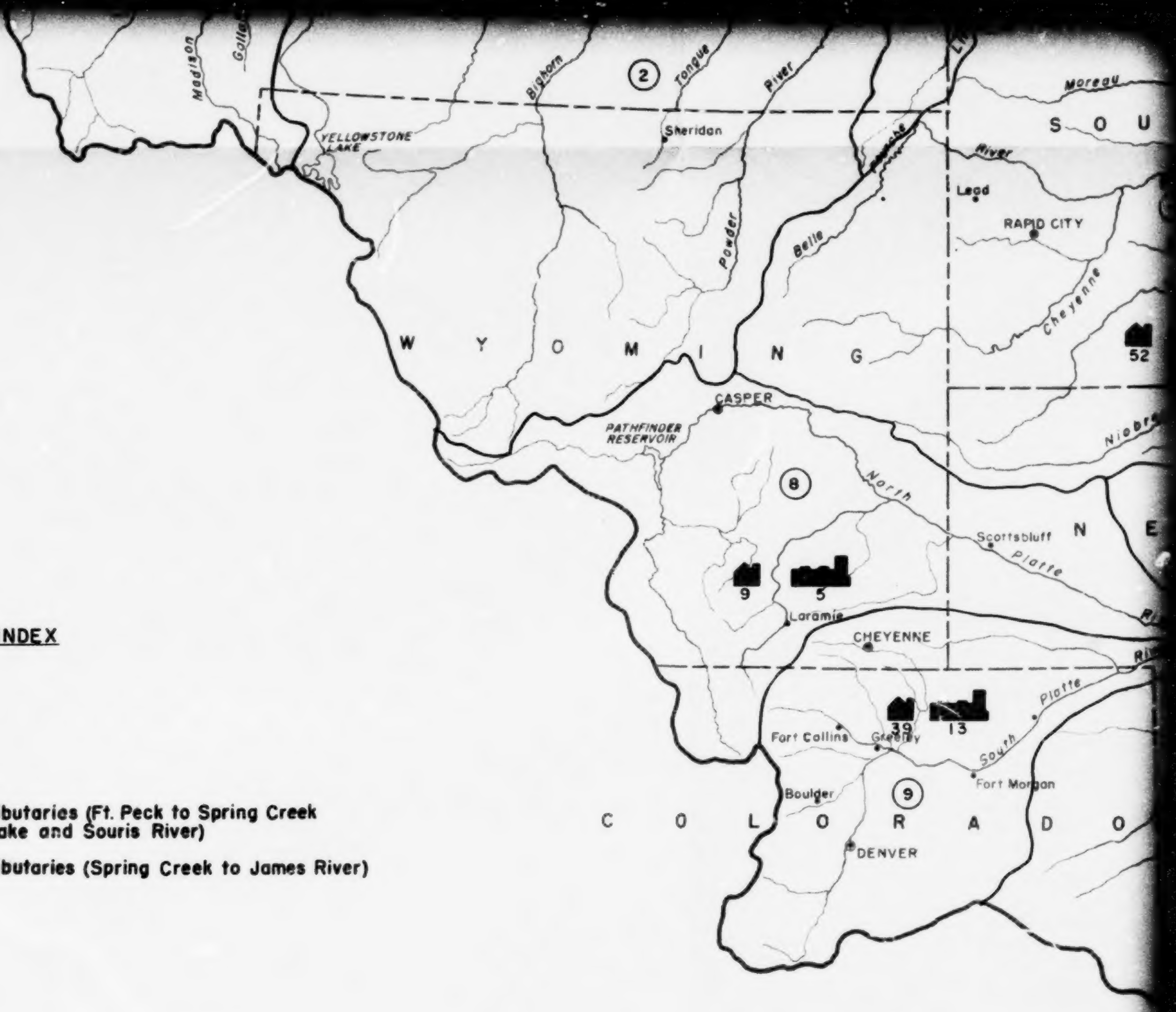
Chariton River
11
12
Chillicothe
River
RIVER
Falls City
Republican
River
McCook
ST. JOSEPH
10
M I S S O U R I
Concordia
112
5
Richmond
Marshall
Lexington
MISSISSIPPI
Solomon
K A N S A S
KANSAS CITY
INDEPENDENCE
KANSAS CITY
Columbia
Fulton
St. Charles
Manhattan
Kansas
River
Boonville
Abilene
Junction City
TOPEKA
Warrensburg
Sedalia
JEFFERSON CITY
Saline
River
Hays
SALINA
Smoky
Hill
River
Ottawa
Clinton
River
RIVER
Osage
Gasconade
River
13
Fort Scott
Nevada


2
Madison
Tongue
River
Bighorn
YELLOWSTONE LAKE
Sheridan
Moreau
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River
Lead
RAPID CITY
Belle
Powder
Cheyenne
52
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CASPER
PATHFINDER RESERVOIR
8
North
Niobra
Scottsbluff
N E
Platte
9
5
Laramie
CHEYENNE
39
13
Fort Collins
Greeley
Platte
South
Fort Morgan
Boulder
9
C O L O R A D O
DENVER

SUB-BASIN INDEX

① Upper Missouri

② Yellowstone

③ Main stem and tributaries (Ft. Peck to Spring Creek including Devils Lake and Souris River)

④ Main stem and tributaries (Spring Creek to James River)

⑤ James

⑥ Big Sioux

⑦ Lower Platte

⑧ North Platte

⑨ South Platte

⑩ Kansas

⑪ Main stem and minor tributaries (James to Mouth)

⑫ Grand – Chariton

⑬ Osage-Gasconade

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NUMBER OF EXI

SCALE

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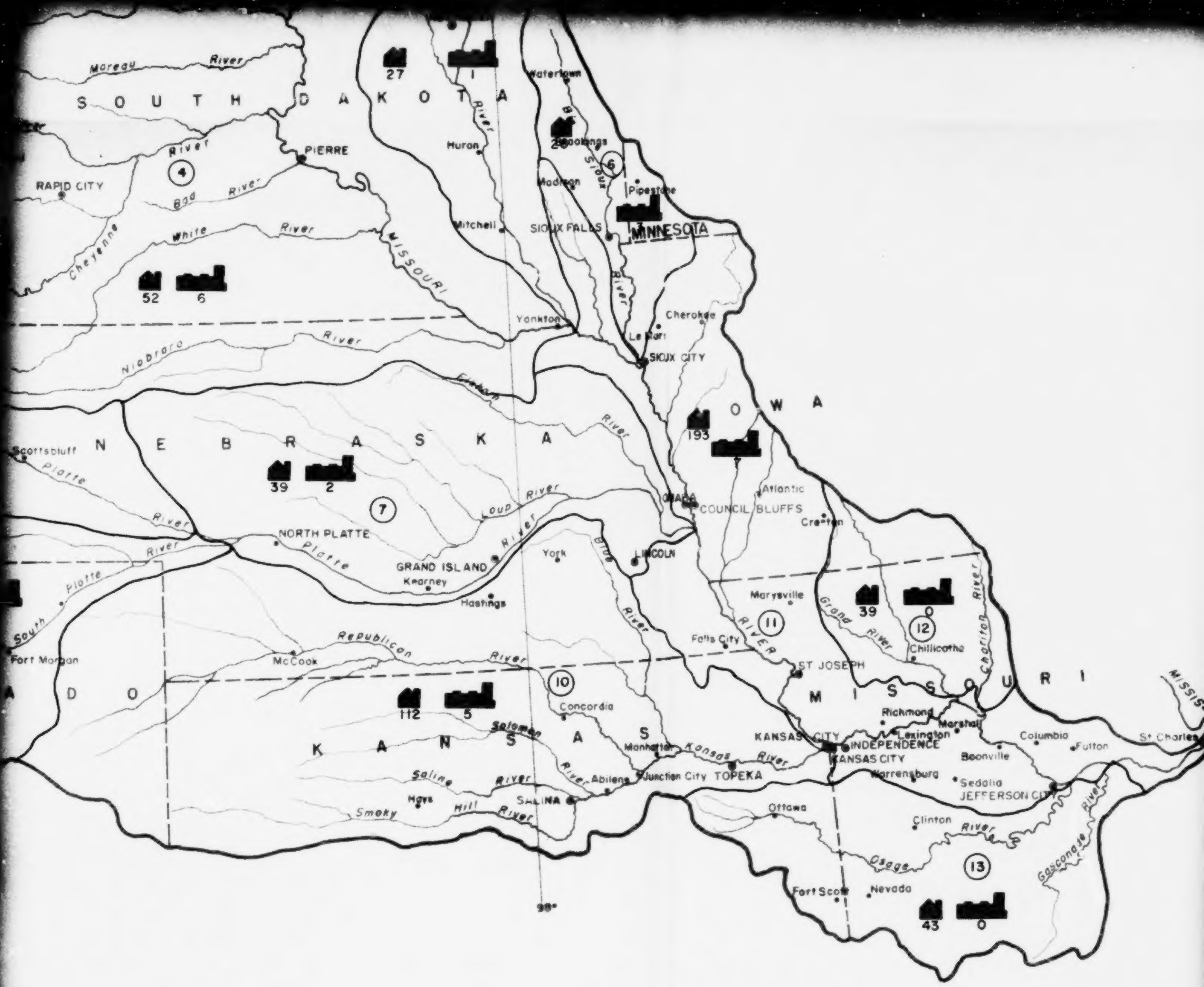

SOUTH DAKOTA
Moreau River
River
PIERRE
RAPID CITY
Bad River
White River
Cheyenne
MISSOURI
Huron
Watertown
Brookings
Madison
Mitchell
SIOUX FALLS
Pipestone
MINNESOTA
Sioux River
Big Sioux
Yankton
Cherokee
Le Mars
SIOUX CITY
IOWA
Niobrara River
Elkhorn River
NEBRASKA
Scottsbluff
Platte River
North Platte
NORTH PLATTE
Loup River
GRAND ISLAND
Kearney
Hastings
York
LINCOLN
OMAHA
COUNCIL BLUFFS
Atlantic
Creston
Blue River
South Platte
Fort Morgan
Republican River
McCook
Concordia
KANSAS
Solomon River
Saline River
Smoky Hill River
Hays
SALINA
Abilene
Junction City
Manhattan
Kansas River
TOPEKA
Marysville
Falls City
ST JOSEPH
Grand River
Chariton River
Chillicothe
MISSOURI
Richmond
Lexington
Marshall
KANSAS CITY
INDEPENDENCE
Columbia
Fulton
St Charles
Boonville
Warrensburg
Sedalia
JEFFERSON CITY
Ottawa
Clinton
Osage River
Gasconade River
Fort Scott
Nevada
MISSISSIPPI
98°
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MISSOURI DRAIN

EXISTING TREATM

NUMBER OF EXISTING MUNICIPAL TREATMENT WORKS

NUMBER OF EXISTING INDUSTRIAL TREATMENT WORKS

FEDERAL SECURIT

Public Health

DIVISION OF WATER PO

MAP NO. 2

SCALE OF MILES

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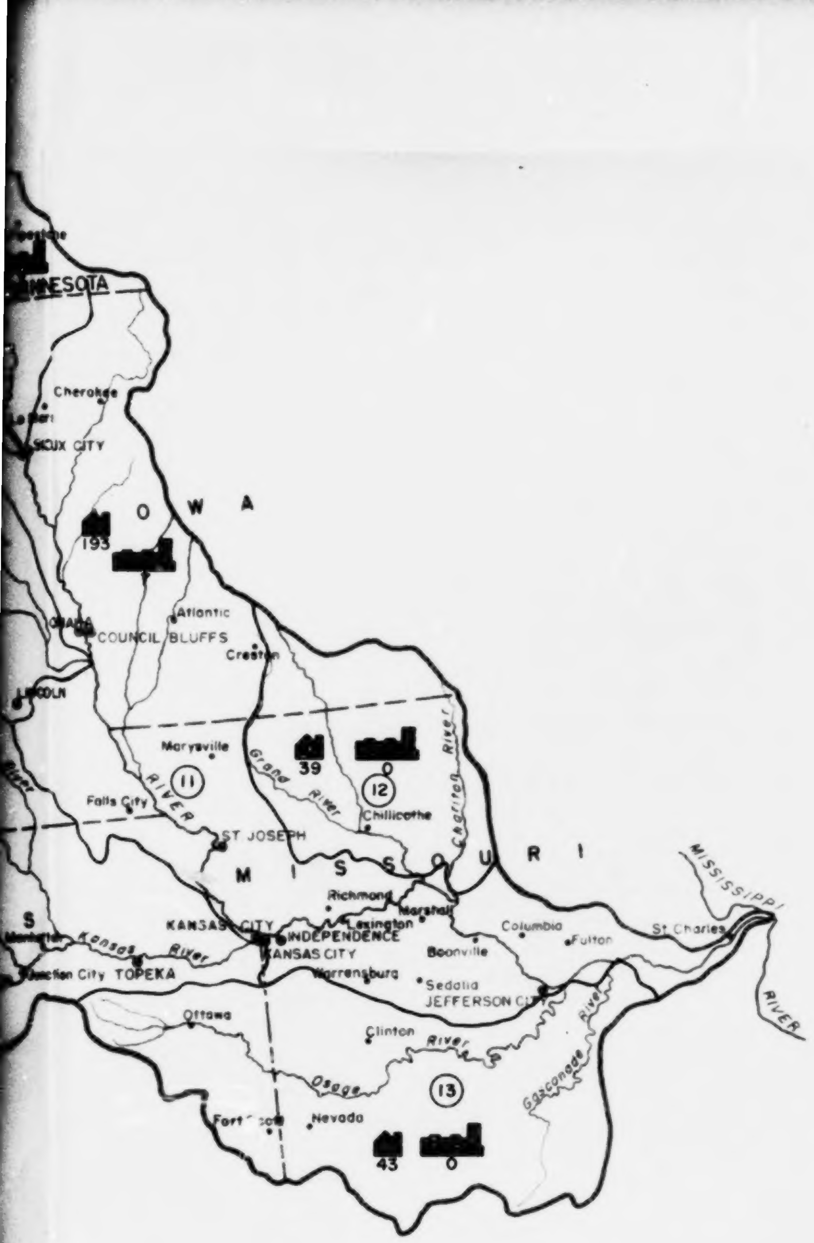
40-B

D


MINNESOTA
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Le Mars
SIOUX CITY
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Atlantic
OMAHA
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Creston
LINCOLN
Marysville
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39
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12
Grand River
Chariton River
Falls City
RIVER
Chillicothe
ST JOSEPH
M I S S O U R I
Richmond
Marshall
Lexington
KANSAS CITY
INDEPENDENCE
KANSAS CITY
Columbia
Fulton
St Charles
MISSISSIPPI
RIVER
S
Manhattan
Kansas River
Junction City
TOPEKA
Boonville
Warrensburg
Sedalia
JEFFERSON CITY
Ottawa
Clinton
River
Osage
13
Gasconade River
Nevada
43
0

MISSOURI DRAINAGE BASIN

EXISTING TREATMENT WORKS

FEDERAL SECURITY AGENCY

Public Health Service

DIVISION OF WATER POLLUTION CONTROL

MAP NO. 2

942709 O - 51 (Face blank p. 40) No. 2

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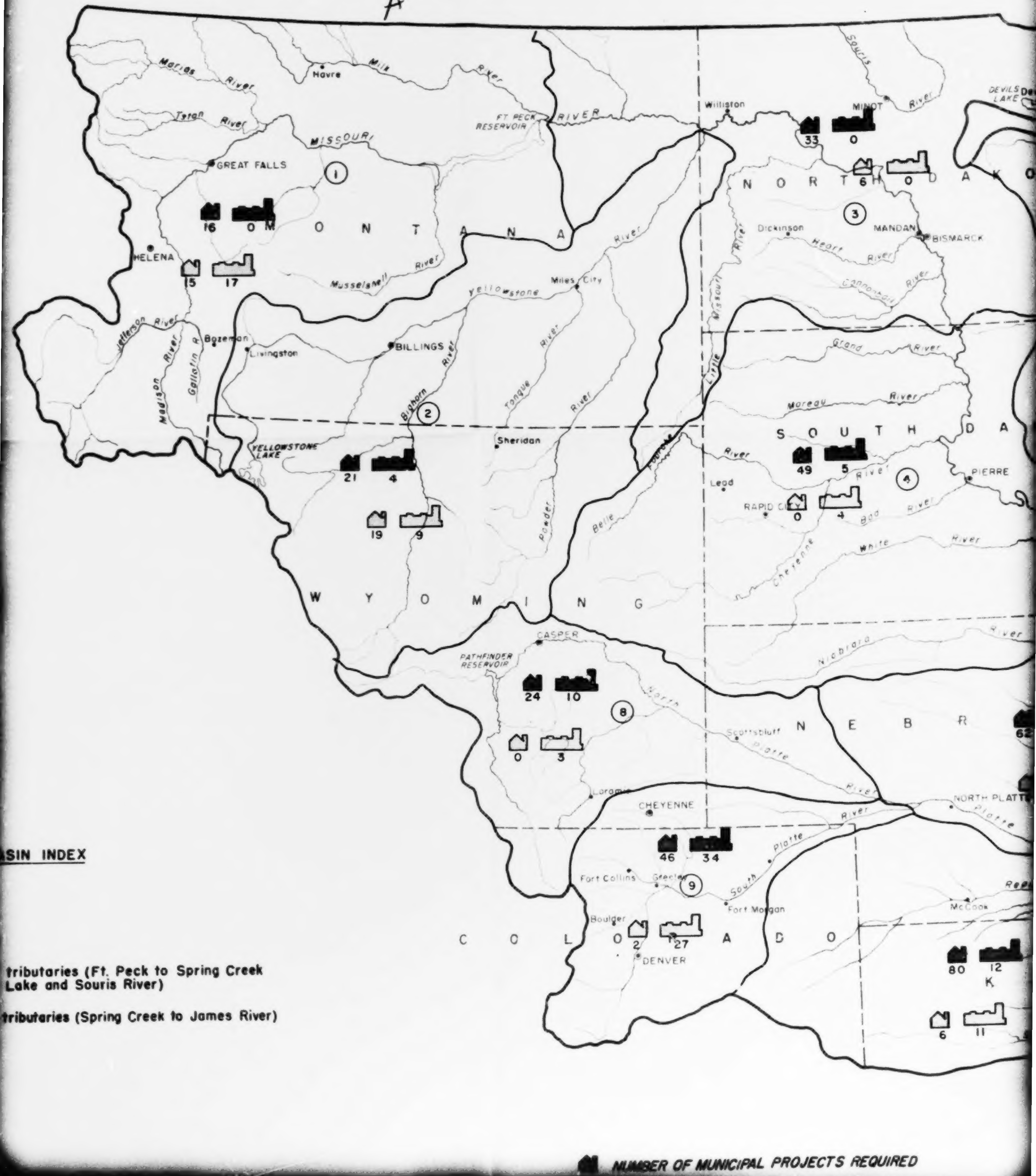
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
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Marias River
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GREAT FALLS
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Jefferson River
Madison River
Gallatin R
Bozeman
Livingston
BILLINGS
Yellowstone River
Miles City
Bighorn River
Tongue River
Powder River
Sheridan
YELLOWSTONE LAKE
Williston
MINOT
Souris River
DEVILS LAKE
Dickinson
MANDAN
BISMARCK
Heart River
Cannonball River
Little Missouri River
Grand River
Moreau River
Belle Fourche River
Lead
RAPID CITY
PIERRE
Bad River
Cheyenne River
White River
Niobrara River
CASPER
PATHFINDER RESERVOIR
North Platte River
Scottsbluff
Laramie
CHEYENNE
NORTH PLATTE
Platte
South Platte River
Fort Collins
Greeley
Fort Morgan
Boulder
DENVER
McCook
Republican River
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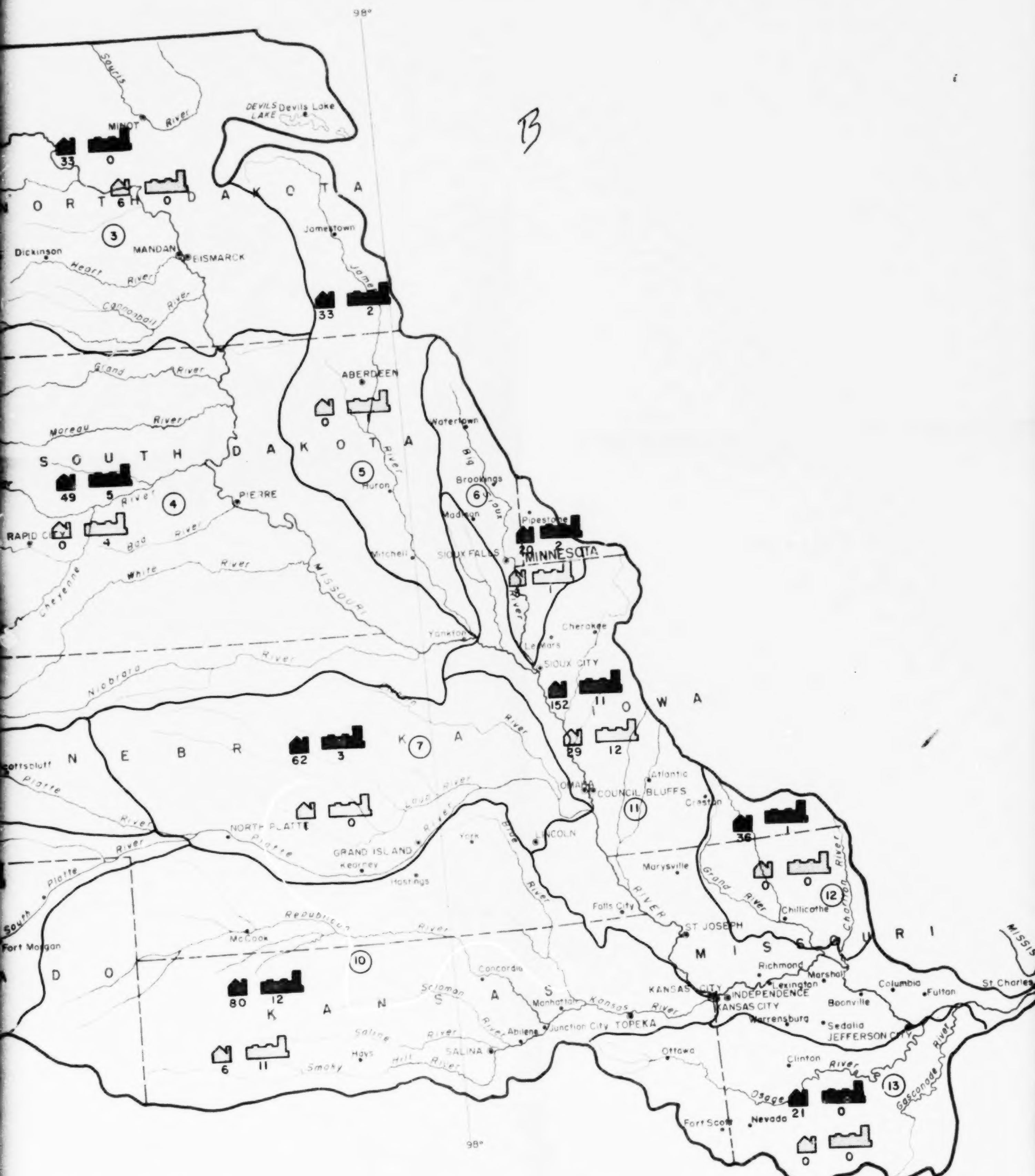
62
SIN INDEX
tributaries (Ft. Peck to Spring Creek Lake and Souris River)
tributaries (Spring Creek to James River)
NUMBER OF MUNICIPAL PROJECTS REQUIRED

B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Dickinson
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BISMARCK
Heart River
Cannonball River
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Grand River
Moreau River
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Watertown
Big Sioux
Brookings
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Huron
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River
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PIERRE
RAPID CITY
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Pipestone
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Mitchell
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White River
Cheyenne
MISSOURI
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Yankton
Cherokee
Le Mars
SIOUX CITY
Niobrara River
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I O W A
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N E B R A S K A
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62
3
Scottsbluff
Platte River
River
Loup River
0
NORTH PLATTE
Platte
Atlantic
OMAHA
COUNCIL BLUFFS
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Creston
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York
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GRAND ISLAND
Kearney
Hastings
River
South Platte
Fort Morgan
Marysville
Grand River
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Chillicothe
Falls City
RIVER
ST JOSEPH
Republican River
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Concordia
Richmond
Marshall
Lexington
Columbia
Fulton
St Charles
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Kansas River
KANSAS CITY
INDEPENDENCE
KANSAS CITY
Boonville
Warrensburg
Sedalia
JEFFERSON CITY
Saline River
Abilene
Junction City
TOPEKA
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Hays
Smoky Hill River
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Ottawa
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River
Osage
Gasconade River
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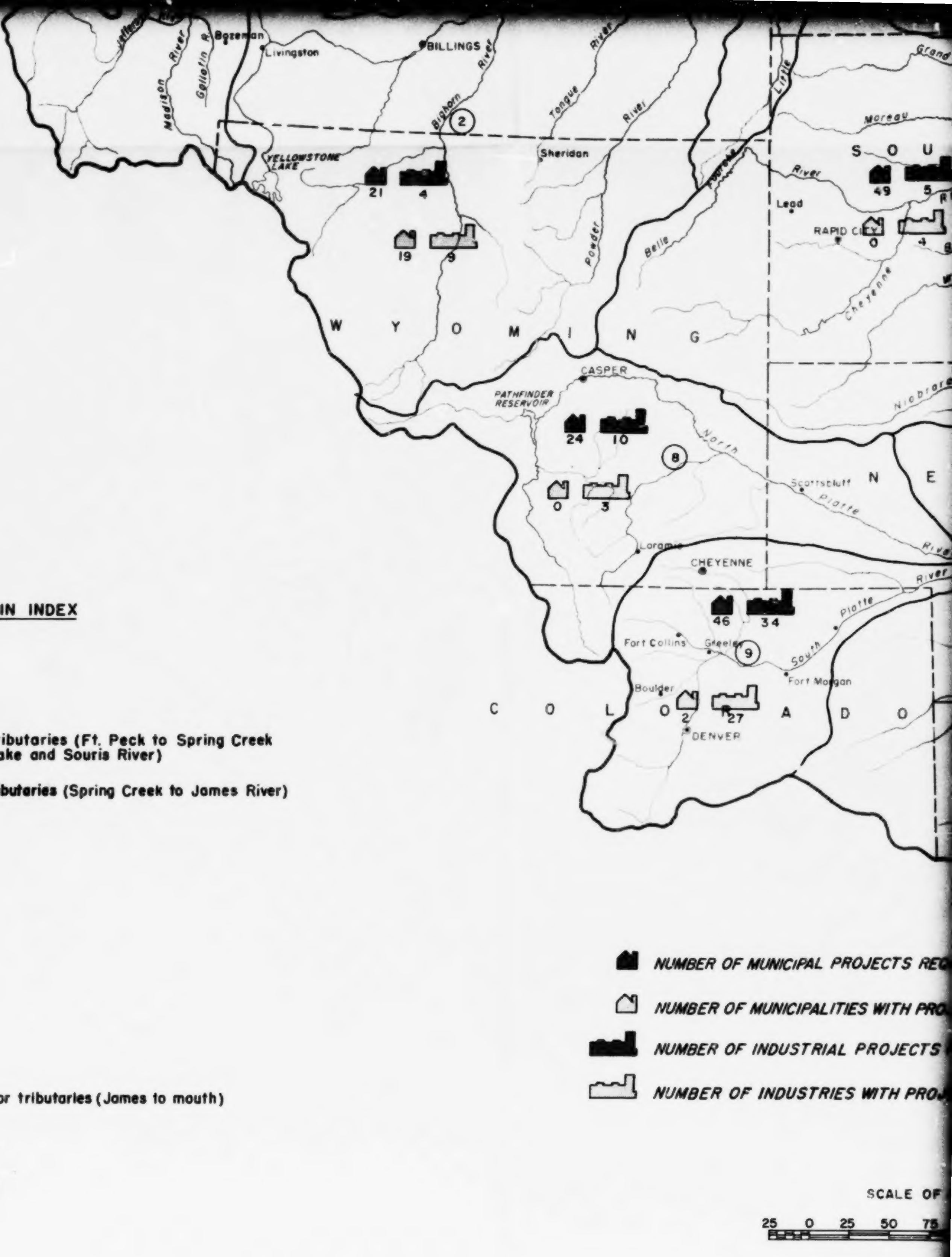
98°

CIPAL PROJECTS REQUIRED


Bozeman
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Jefferson River
Madison River
Gallatin R.
Bighorn River
Tongue River
Powder River
Belle Fourche
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Grand
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Cheyenne
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CASPER
PATHFINDER RESERVOIR
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Scottsbluff
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Laramie
CHEYENNE
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Fort Collins
Greeley
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South Platte River
Fort Morgan
Boulder
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DENVER
C O L O R A D O
NUMBER OF MUNICIPAL PROJECTS RE
NUMBER OF MUNICIPALITIES WITH PRO
NUMBER OF INDUSTRIAL PROJECTS
NUMBER OF INDUSTRIES WITH PRO
SCALE OF
25 0 25 50 75

SUB-BASIN INDEX

① Upper Missouri

② Yellowstone

③ Main stem and tributaries (Ft. Peck to Spring Creek including Devils Lake and Souris River)

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⑦ Lower Platte

⑧ North Platte

⑨ South Platte

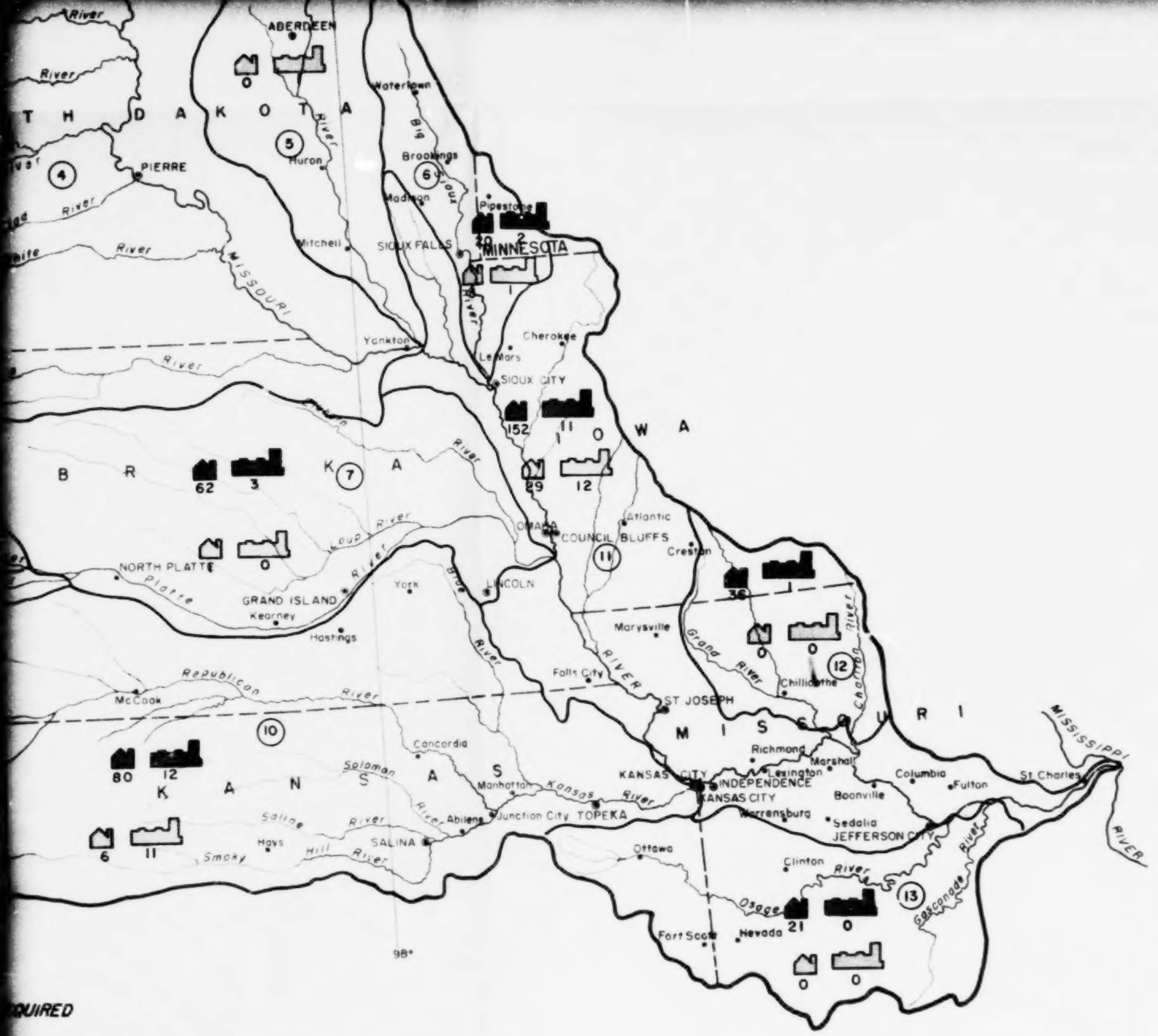
⑩ Kansas

⑪ Main stem and minor tributaries (James to mouth)

⑫ Grand - Chariton

⑬ Osage - Gasconade

C


River
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Bad River
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Cherokee
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Atlantic
OMAHA
COUNCIL BLUFFS
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LINCOLN
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Richmond
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KANSAS CITY
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Fulton
St Charles
Manhattan
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Junction City
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Sedalia
JEFFERSON CITY
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SALINA
Smoky
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Fort Scott
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QUIRED

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JECT REQUIREMENTS UNDETERMINED

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MISSOURI DRAINAGE BASI

PROJECTS REQUIRED

FEDERAL SECURITY AGENCY

Public Health Service

DIVISION OF WATER POLLUTION CONT

MAP NO. 3

942709 O - 51 (Face blank p. 4

o-C.

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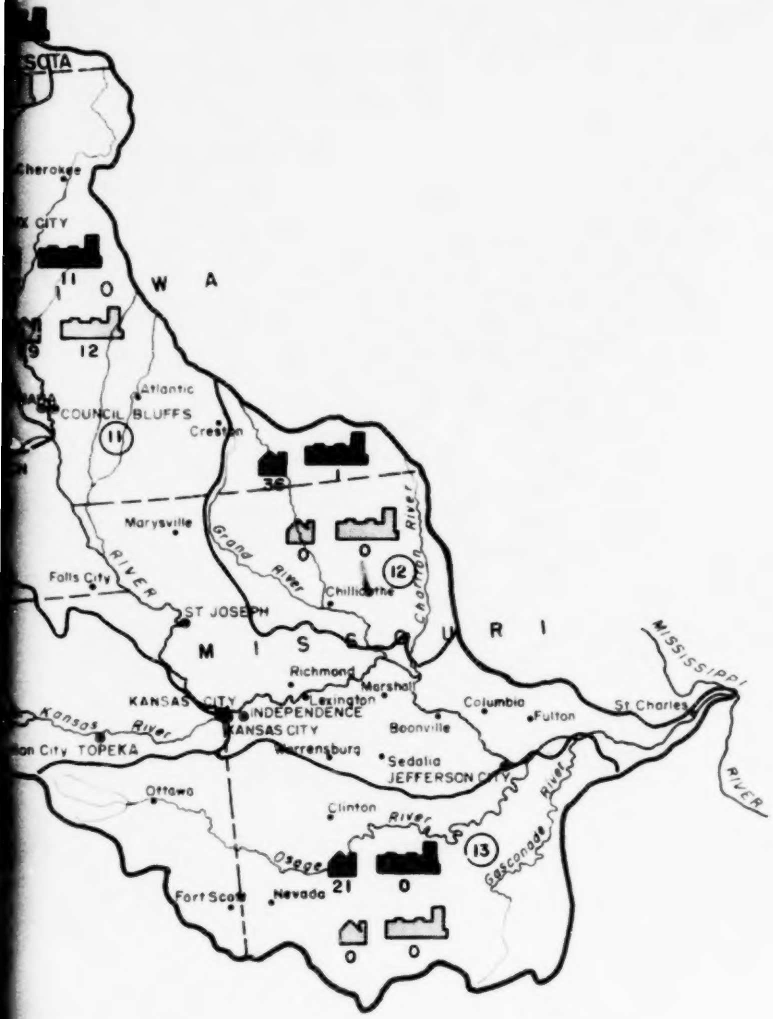
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RIVER
St JOSEPH
Chillicothe
M I S S O U R I
Richmond
Lexington
Marshall
KANSAS CITY
INDEPENDENCE
KANSAS CITY
Columbia
Fulton
St Charles
MISSISSIPPI RIVER
Kansas River
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Warrensburg
Sedalia
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Osage River
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Fort Scott
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MISSOURI DRAINAGE BASIN

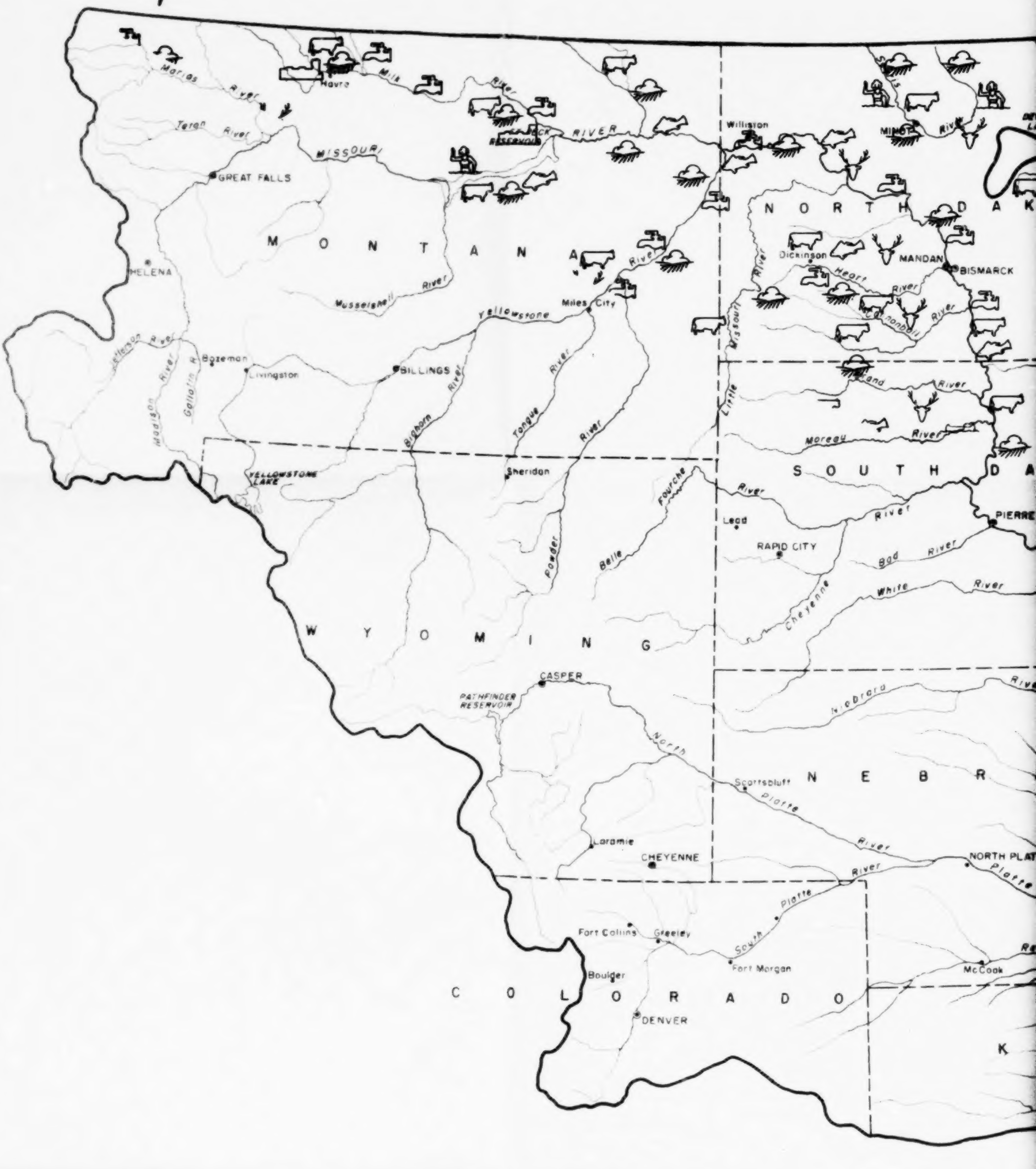
PROJECTS REQUIRED

FEDERAL SECURITY AGENCY
Public Health Service
DIVISION OF WATER POLLUTION CONTROL
MAP NO. 3

942709 O - 51 (Face blank p. 40) No. 3

E

A



MONTANA
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SOUTH DA
WYOMING
NEBR
COLORADO
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Marias River
Teton River
Milk River
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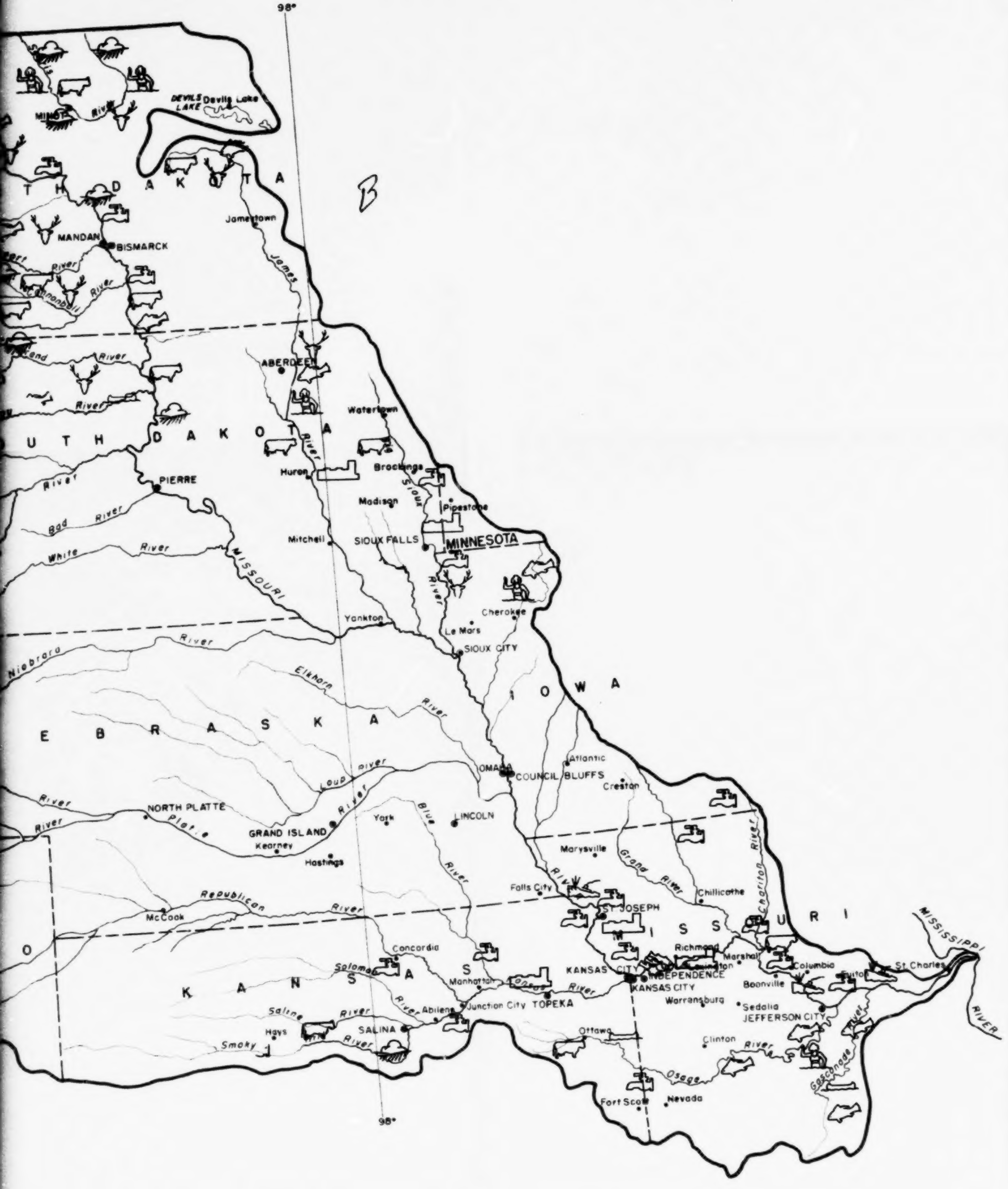
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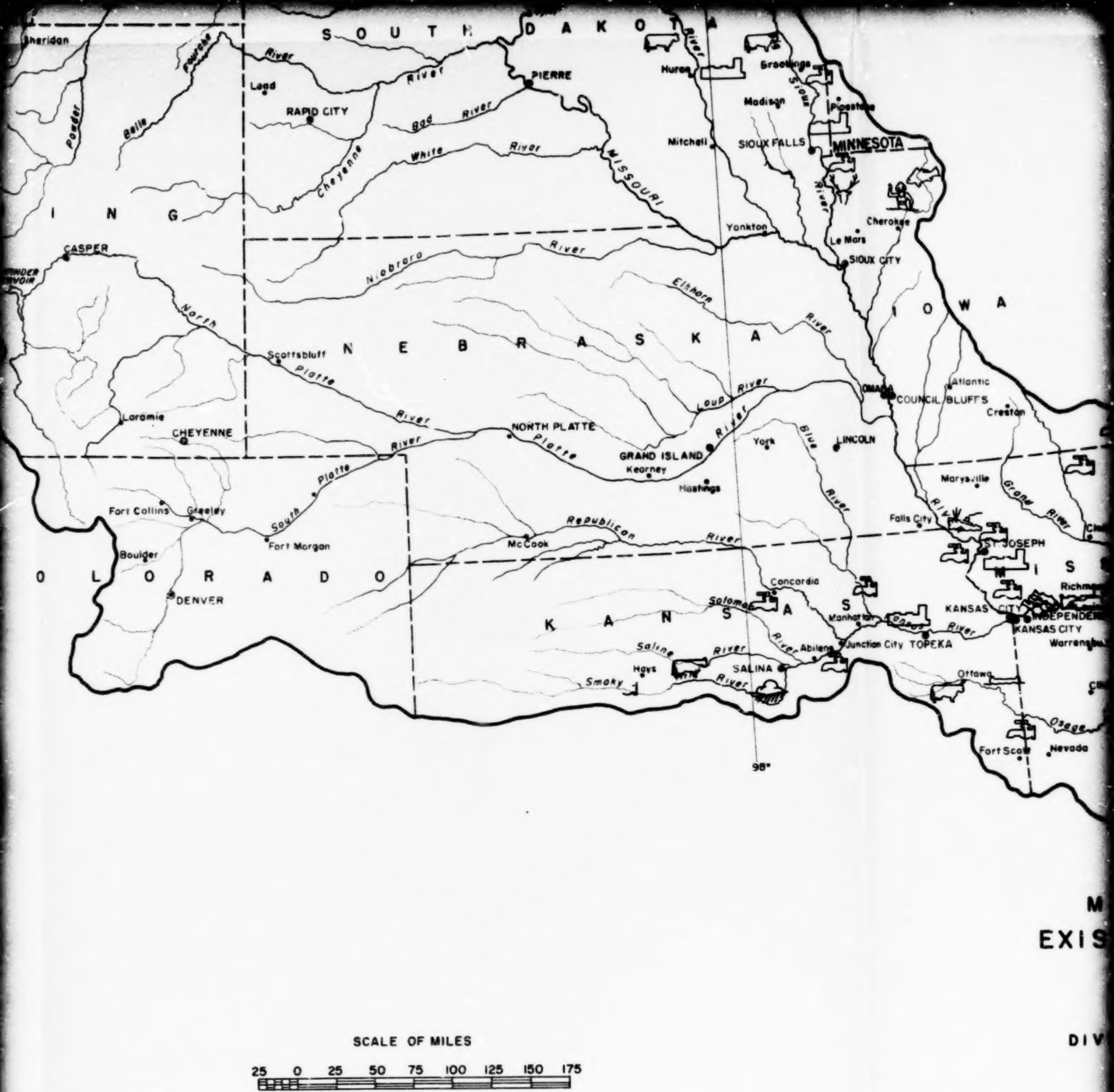
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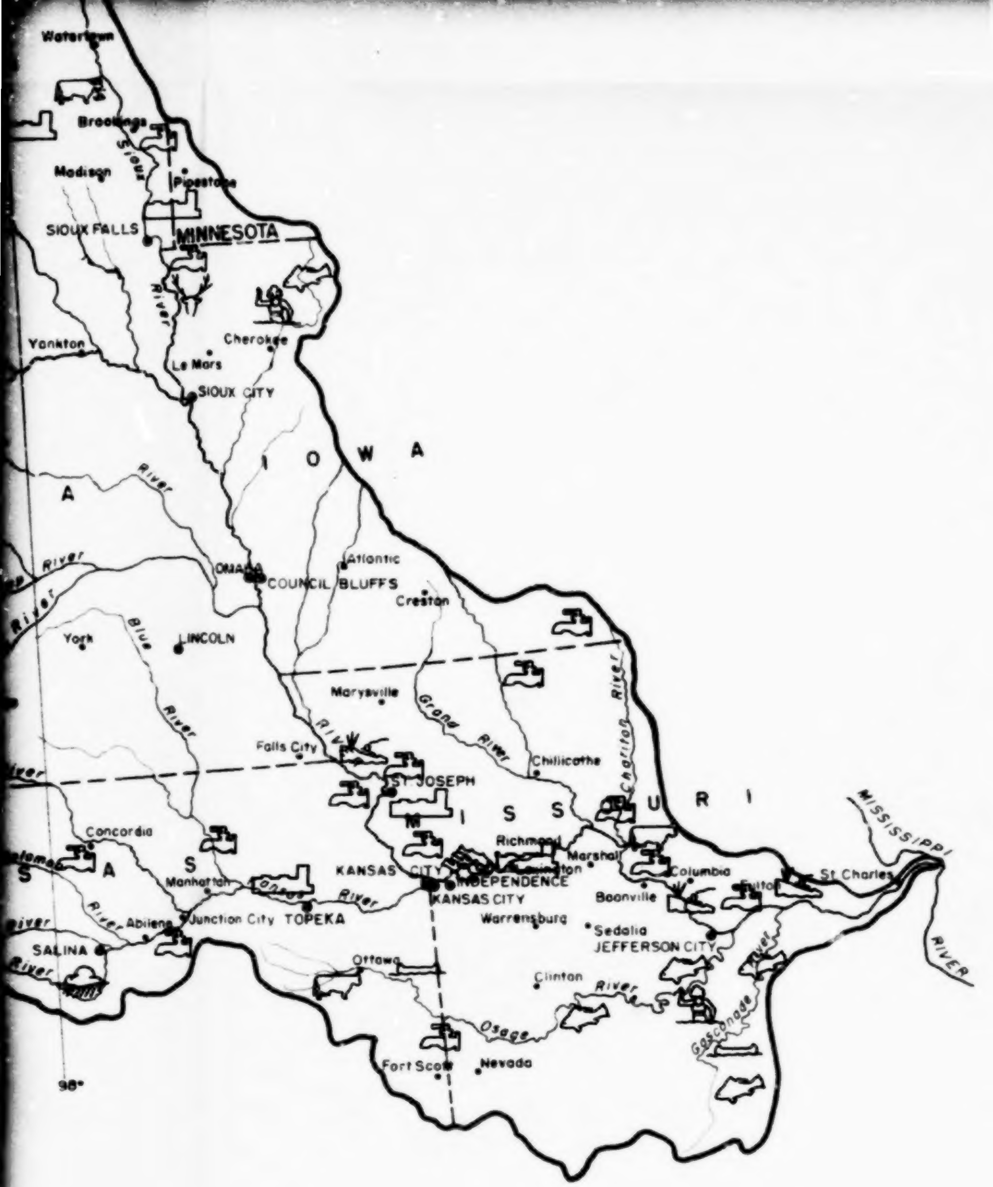
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MISSOURI DRAINAGE BASIN
EXISTING PRIMARY WATER USES

FEDERAL SECURITY AGENCY
Public Health Service
DIVISION OF WATER POLLUTION CONTROL

MAP NO. 4

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D

SUB-BASIN REPORTS

UPPER MISSOURI RIVER SUB-BASIN

Physical Description

Geography - This Sub-Basin, with a maximum width of approximately 315 miles and a length of 450 miles, occupies parts of the States of Montana and Wyoming. The area encompasses approximately 81,200 square miles which represents 15 percent of the total area of the Missouri Basin. The natural boundaries are formed by the Continental Divide on the west, the Hudson Bay Divide to the north, the Poplar River Watershed to the east, and the Yellowstone Sub-Basin to the south.

Topography - The Upper Missouri River rises along the eastern slope of the Rocky Mountains and lies almost wholly within the State of Montana. Its major tributaries are the Jefferson, Madison, Gallatin, Musselshell, and Milk Rivers, whose flow are derived principally from springs and snow-fed mountain streams. The Missouri River in its upper reaches is a clear, turbulent stream with an average slope of 4.5 feet per mile. It is estimated that 5 million acre-feet of water is contributed annually to the main stem of the Missouri River from tributaries in this portion of the Missouri Basin.

The elevations of the Sub-Basin vary greatly due to the high mountains and high plateau area. The headwaters rise in rugged mountain ranges having elevations up to 13,000 feet. The lower end of the Basin has an elevation of approximately 3,300 feet at valley bottom. The Missouri River flows out of the mountainous area at a point about 35 miles above Great Falls, Mont., and enters a glaciated and unglaciated region known as the Missouri Plateau. The river leaves the Sub-Basin bounds just below the mouth of the Milk River but continues through the plateau for 1,500 miles, emerging a short way above Yankton, S. Dak.

Climate - Climatological characteristics are those of a semiarid region with an average rainfall of approximately 12 inches, much of which occurs in the form of torrential downpour during the growing season. Temperatures are exceedingly variable and range between a low of -52° F. and a high of 110°. The average annual temperature in the vicinity of Yellowstone Park is 32° F., while in the plains region it is 38° F. Humidity is relatively low.

Economic Development - Agricultural pursuits form the major occupation of the Sub-Basin's population. According to the 1940 census agriculture supported 162,600 persons, or approximately 65 percent of the total population of the Sub-Basin.

The Upper Sub-Basin is quite rich in mineral resources. Gold, silver, lead, zinc, copper, coal, oil and gas are found in quantity. There are large deposits of coal and oil shales which remain to be developed. Limited deposits of rare earth and radioactive material also exist in this region. The principal industries of the Upper Missouri River Sub-Basin are mining, smelting, oil production and refining, food processing, and resort and tourist operations. In recent years there has been a marked increase in industrial operations throughout the Sub-Basin, and the urban populations have increased.

The natural beauty of the mountainous regions lying within the Upper Sub-Basin, and primarily within the National Park System, are responsible for a large tourist and resort industry which contributes substantially to the Sub-Basin's income.

Uses of Water Resources - The water resources of the upper river have been primarily responsible for its development. The rapid flowing river has provided power for industry, the volume of water available has made irrigation feasible, and the clean water has provided a readily accessible supply for both municipal and industrial uses. The many mountain streams have provided excellent fishing, which has added materially to the other attractions of the region, and have brought an increasing volume of tourist trade each year. It may be expected that industry will continue to expand, particularly new industries such as the production of liquid fuels from the large deposits of lignite and coal. The feasibility of this development is enhanced by the presence of large volumes of water, so necessary to the processing of these fuels. The Upper Missouri River Sub-Basin shows every likelihood of becoming a highly industrialized area.

The residents of the Upper Missouri River Sub-Basin are cognizant of the need to develop the resources of the Sub-Basin to their fullest extent, and water resources have received early attention. It is important that proper recognition be given to problems of domestic water supply and sanitation, as they may affect general water resources development of the Sub-Basin.

Pollution Data

The volume of industrial and domestic wastes as measured in population equivalents, together with the present status of pollution control facilities and further needs, are illustrated in tables $A_{(1)}$ through $I_{(1)}$. Footnote to table $A_{(1)}$ indicates that a relatively small amount of industrial waste is being discharged to municipal sewage systems in the Upper Missouri River Sub-Basin. It is evident that 10 percent of the known municipal waste B.O.D. is removed prior to discharge to watercourses. This analysis applies to those sources of pollution for which data are available. Industrial wastes sources as shown in table $B_{(1)}$ are relatively few in number. However they are of the type (table $D_{(1)}$) which may be responsible for polluting considerable stretches of the stream. It will be noted that 3 plants discharge seasonal wastes. These plants are beet sugar refineries whose population equivalent has not yet been determined. The pollution of the Milk River has constituted a major problem within this sub-basin. The stream lies entirely within the State of Montana, and the water pollution control agency of that State has concentrated its effort on controlling the pollution in this stream.

Table $C_{(1)}$ indicates that 66 percent of the municipalities having sewer systems are provided with some type of treatment facilities.

Table $D_{(1)}$ indicates that there is some degree of treatment at 3 of the 17 industrial plants. The petroleum industry leads over other types of industry in the number of waste outlets. The table also indicates that insufficient data are available to classify approximately two-thirds of the industrial waste treatment facilities.

Table $E_{(1)}$ suggests that 28 percent of the municipal treatment plants have adequate capacity, and that 51 percent (table $G_{(1)}$) of the population connected to sewage systems for which treatment needs have been determined is thus adequately provided with treatment facilities.

Table $F_{(1)}$ indicates that there have been no new municipal sewage treatment works constructed in the Upper Missouri Sub-Basin during the period 1946 through 1949, but that one new industrial waste

treatment facility was constructed in 1947.

Table $H_{(1)}$ indicates that 4 of the 16 municipalities for which requirements have been determined have initiated action, 2 of which have already begun construction.

Table $I_{(1)}$ lists the project needs of the individual municipalities and industries. Project requirements listed are in some cases based on incomplete information and are subject to change after investigations have been completed by the State agency concerned.

Table $A_{(1)}$ - Sources of pollution - Municipal

Municipalities*	Sources of pollution (In number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (In terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	35	111,900***	102,000
Having population data available (Data on pollution load to watercourse incomplete or not available)	3	10,700	Not applicable
Total	38	122,600	102,000

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers, or other population centers; sanitary sewage wastes discharged by industry directly to watercourse.

** Includes industrial wastes discharged into municipal sewerage systems.

*** Does not include industrial waste of 1,100 population equivalents.

Table $B_{(1)}$ - Sources of pollution - Industrial*

Industries	Sources of pollution (In number of plants)	Amount of pollution discharged to watercourse (In terms of equivalent number of people)
Producing organic wastes	0	- - - -
Producing organic wastes	8**	Undetermined
Producing inorganic wastes	15	Not applicable
Producing wastes of undetermined type	0	- - - -
Total	17***	- - - -

* Industries having separate outlets and discharging wastes directly to watercourse.

** Includes 6 plants also producing inorganic wastes. Wastes from 3 plants are seasonal.

*** Total adjusted to correct for duplication noted in footnote marked **.

Table $C_{(1)}$ - Existing treatment facilities - Municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	23	23	39,100
Secondary	2	2	2,600
No treatment	13	- - - -	80,900

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

Table $D_{(1)}$ - Existing treatment facilities - Industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food & kindred products -------------	3	1	1	1
Prod. of petrol. & coal --------------	5	1	- - - -	4
Primary metal industries ----------	3	- - - -	1	2
Miscellaneous -----	3	1	1	1
Other mining industries ----------	3	- - - -	- - - -	3
Total	17	3	3	11

* Industries having separate outlets and discharging wastes directly to watercourse.

Table $E_{(1)}$ - Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	25	7	12	6	10	10	5
Industrial	3	0	0	3	0	0	3

Table $F_{(1)}$ - Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (In terms of equivalent number of people)
1946	0	- - - -	0	- - - -
1947	0	- - - -	1	Unknown
1948	0	- - - -	0	- - - -
1949	0	- - - -	0	- - - -

Table $G_{(1)}$ - Requirements for municipal and industrial waste treatment plants

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	12	43,200	0
Enlargement or additions to existing plant	4	11,600	0
Replace existing plant	0	- - - -	0
No project required	7	56,900	0
Undetermined	15*	10,900	17

* Includes one municipality where no treatment facilities now exist and need for treatment not determined.

Table $H_{(1)}$ - Status of treatment works project to abate pollution - July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	0	0
Abatement ordered *	0	0
Plans under preparation	2	0
Final plans approved	0	0
Construction awaiting financing	0	0
Under construction	2	0
Status undetermined	12	0

(Footnote continued)

(Footnote for Table $H_{(1)}$)

* Formal orders to municipalities and industries for abatement of pollution have received little use as an administrative procedure in the Upper Missouri Sub-Basin. Instead, State water pollution control agencies have preferred to use a cooperative approach, working closely with polluters in an attempt to secure abatement without exercise of police power. Formal orders have in general been used only in recalcitrant cases where the cooperative approach has not been successful. Acceleration of abatement activities in this Sub-Basin may conceivably increase the use of formal orders as an administrative expedient.

Table $I_{(1)}$ - Project list - Municipalities and industries requiring improvements for abatement of pollution - July 1, 1950

Name	Population served	Project requirements	Remarks
Montana:			
Dillon --------	5,200	New plant needed	- - - -
Mines-------	Not known	Needs undetermined	- - - -
Silver Star Mines-------	Not known	Needs undetermined	- - - -
Twin Bridges State Orphans' Home -------	350	New plant needed	- - - -
Whitehall -----	750	Needs undetermined	- - - -
Boulder State Training School ------	514	New plant needed	- - - -
Three Forks --	900	Needs undetermined	- - - -
Bozeman Bozeman Pea Cannery-----	Not known	Needs undetermined	- - - -
Belgrade -----	618	Needs undetermined	- - - -
Manhattan ----	560	Needs undetermined	- - - -
Trident-------	160	Needs undetermined	- - - -
Townsend-----	1,500	Enlarge existing plant	- - - -
Helena -------	16,150	New plant needed	Planning initiated
East Helena---	1,150	Enlarge existing plant	- - - -
A. C. M. Smelter	Not known	Needs undetermined	- - - -
A. S. & R. Smelter -----	Not known	Needs undetermined	- - - -

Table $I_{(1)}$ - (Continued)

Table $I_{(1)}$ - (Continued)

Name	Population served	Project requirements	Remarks
White Sulphur Springs-------	600	New plant needed	- - - -
Great Falls G. N. Railroad Shops -------	Not known	Needs undetermined	- - - -
Phillips Oil Ref.	Not known	Needs undetermined	- - - -
A. C. M. Smelter-------	Not known	Needs undetermined	- - - -
Great Falls Meat Co.------	Not known	Needs undetermined	- - - -
Niehart Lead and Silver Mines-	Not known	Needs undetermined	- - - -
Fort Benton---	1, 200	Needs undetermined	- - - -
Choteau ------	1, 188	New plant needed	Planning initiated
Browning -----	1, 200	Needs undetermined	- - - -
Cut Bank -----	3, 500	New plant needed	- - - -
Carter Oil Refinery-----	Not known	Needs undetermined	- - - -
Union Oil Refinery-----	Not known	Needs undetermined	- - - -
Sunburst------	710	Needs undetermined	- - - -
Texas Oil Refinery-----	Not known	Needs undetermined	- - - -
Kevin Oil Refinery -	Not known	Needs undetermined	- - - -
Shelby--------	719	Needs undetermined	- - - -

Table $I_{(1)}$ - (Continued)

Table $I_{(1)}$ - (Continued)

Name	Population served	Project requirements	Remarks
Geraldine	262	Needs undetermined	- - - -
Lewistown	5, 700	Enlarge existing plant	- - - -
Harlowton	1, 500	New plant needed	- - - -
Railroad Shops	Not known	Needs undetermined	- - - -
Roundup	3, 300	Enlarge existing plant	- - - -
Winnett	150	Needs undetermined	- - - -
Big Sandy	500	Needs undetermined	- - - -
Havre	8, 500	New plant needed	Under construction
G. N. Railroad Shops	Not known	Needs undetermined	- - - -
Chinook			
U. & I. Sugar Co.	Not known	Needs undetermined	- - - -
Harlem	1, 166	New plant needed	Under construction
Malta	2, 000	Needs undetermined	- - - -
Saco	500	Needs undetermined	- - - -
Hinsdale	699	Needs undetermined	- - - -
Glasgow	3, 600	New plant needed	- - - -
Nashua	925	New plant needed	- - - -

YELLOWSTONE RIVER SUB-BASIN

Physical Description

Geography - This Sub-Basin has a maximum width of 310 miles, a length of 465 miles, and occupies parts of the States of Montana, Wyoming, and North Dakota. The area totals approximately 70,800 square miles representing 13 percent of the Missouri River Basin. The natural boundaries are formed by the Continental Divide on the west, the Upper Missouri River watershed to the north, the Little Missouri and Belle Fourche River watersheds to the east, and the North Platte River Drainage Sub-Basin to the south.

Topography - The headwaters of the Yellowstone River are formed high in the mountains within Yellowstone National Park. The length of the Yellowstone River is about 670 miles. Its principal tributaries are Boulder, Clarks Fork, Big Horn, Tongue, and Powder Rivers. Runoff from Yellowstone Sub-Basin contributes approximately 6,800,000 acre-feet of water annually to the main stem of the Missouri River.

The physical features of the Yellowstone Sub-Basin are generally characterized by foothills and rugged mountain ranges. The eastern and northerly portions of the Sub-Basin extend into the Missouri plateau section of the Great Plains. Mesas are found interspersed among the benchlands of this portion of the Sub-Basin. There are numerous lakes located in the mountainous region, of which Yellowstone Lake is the largest.

Climate - The extreme elevations found in this Sub-Basin contribute largely to the extremes of temperature. The mean annual temperature in the mountainous region is approximately 32° F., while that in the greater plains region is about 46° F. Maximum temperatures of 117° have been reported at Glendive, Mont., and a minimum of -65° has been reported from Miles City, Mont. Precipitation in the Sub-Basin is sparse and averages approximately 12 inches per year. It is necessary to irrigate most crops in order to assure a harvest.

Hydrology - Most of the water in the Yellowstone and its tributaries originates from melting snows in the high mountain ranges and from numerous springs issuing from canyon walls. The mean annual flow at the point of confluence with the Missouri River is 11,000 second-feet. The lowest recorded flow for the period of one day at this point was 1,400 second-feet.

The waters of the Yellowstone are sufficiently mineralized in its lower reaches to necessitate proper drainage of irrigated land in order that unduly large concentrations of salt are not built up in the soil. The water in the upper reaches of the Yellowstone and tributaries is clear and free from extensive mineralization, and is readily usable for the propagation of fish life, recreational purposes, irrigation and municipal water supplies; however as the stream progresses great quantities of silt and considerable amounts of mineral matter are acquired. It is estimated that 23 percent of all silt carried by the Missouri River past Kansas City, Mo., is contributed by the Yellowstone system. The silt carried by the stream poses a problem for both irrigation projects and users of water for domestic purposes. Few if any fish are able to survive in the lower reaches, and little use is made of the lower river for recreational purposes.

Economic Development - The Yellowstone Sub-Basin supported a population of 212,000 people in 1940. About one-third of the population was engaged in farming or livestock raising, and the remainder in industry and service operations. Intensive irrigation practiced in some portions of the Sub-Basin since the early 1880s forms the backbone of the farming operation. Livestock feed and sugar beets are the principal farm produce.

Mineral resources of the Yellowstone River Sub-Basin include coal, gypsum, bentonite, sulphur, phosphate, gold, chromite, copper, tungsten, silver, iron, zinc, lead, and molybdenum. Nickel and platinum are found in the mountainous sections of the Sub-Basin.

The production and processing of gas and oil is a major industry. The extensive deposits of phosphate rock may become the principal future source of phosphate fertilizer for the great middle western agriculture region.

Yellowstone National Park with its natural wonders attracts thousands of visitors. The other resort places in this vicinity contribute to a large tourist trade which contributes substantially to the income of this area.

Pollution Data

A summation of the data on source and amounts of pollution, together with the kind and amount of treatment installed and needed, is shown in tables $A_{(2)}$ through $I_{(2)}$.

Table $A_{(2)}$ indicates that at least 15 percent of the B.O.D. in terms of population equivalent units is removed by treatment. The footnote under table $A_{(2)}$ shows that in addition to the domestic population, approximately 500 population equivalent units from industrial sources are discharged to municipal sewers.

Table $B_{(2)}$ indicates that most of the organic wastes produced by industry are of a seasonal nature.

Table $C_{(2)}$ shows that 53 percent of the sewered municipalities have sewage treatment installations and 55 percent of the population connected to sewer systems is provided sewage treatment service.

Table $D_{(2)}$ indicates that petroleum refining installations lead in the number of industrial plants. Miscellaneous plants include roundhouse and railroad repair shop installations.

Table $E_{(2)}$ indicates that the capacity of sewage treatment plants in the Yellowstone River Sub-Basin is satisfactory in about one-third of the municipalities and in about two-thirds of the industries having waste treatment facilities. The number of plants being satisfactorily operated is somewhat greater than the number having adequate facilities.

Table $F_{(2)}$ indicates that 1 new municipal sewage treatment plant and 4 new industrial waste treatment plants were constructed during the period 1946 through 1949.

Table $G_{(2)}$ points out the known need for 14 new treatment plants for municipalities, and 2 new industrial waste treatment works, and improvements for 7 municipal and 2 industrial waste treatment plants now existing. It is estimated that improved service is needed for 57 percent of the population connected to sewerage systems for which treatment requirements have been determined.

Table $H_{(2)}$ shows that 5 municipalities, representing 24 percent of the municipalities for which requirements have been determined, have begun action to bring about improvements as needed.

Table $I_{(2)}$ indicates the individual municipal and industrial waste treatment requirements. In some cases the requirements are based on incomplete information and may be subject to change when further investigations are made by the State water pollution control agency concerned.

In addition to the industrial wastes of an organic nature, considerable amounts of silt and toxic material are discharged to the streams from mining operations, beet sugar refineries, and from oil production and refining. The contamination of the streams with toxic materials may be serious at times, since such contaminants are not readily removed by the natural purification process occurring in the streams.

Pollution became so serious that the Montana State Board of Health ordered a sewage treatment works constructed to treat the industrial and domestic wastes at Billings. In addition to treated wastes from the city, partially treated and raw wastes from three oil refineries, two meat packing plants, a sugar refinery and a railroad roundhouse continue to enter the Yellowstone River in the vicinity of Billings.

Table $A_{(2)}$ - Sources of pollution - Municipal

Municipalities*	Sources of pollution (In number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (In terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	50	95,800***	81,700
Having population data available (Data on pollution load to watercourse incomplete or not available)	1	30,000	Not applicable
Total	51	125,800	- - - -

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers, or other population centers; sanitary sewage wastes discharged by industry directly to watercourse.

** Includes industrial wastes discharged into municipal sewerage systems.

*** Data do not include industrial waste of 500 population equivalent discharging to municipal sewers.

Table $B_{(2)}$ - Sources of pollution - Industrial*

Industries	Sources of pollution (In number of plants)	Amount of pollution discharged to watercourse (In terms of equivalent number of people)
Producing organic wastes	4**	606,000***
Producing organic wastes	11****	Undetermined***
Producing inorganic wastes	12	Not applicable
Producing wastes of undetermined type	0	- - - -
Total	20*****	- - - -

* Industries having separate outlets and discharging wastes directly to watercourse.

** Includes 2 plants also producing inorganic wastes.

*** Seasonal wastes included.

**** Includes 5 plants also producing inorganic wastes.

***** Total adjusted to correct for duplication noted in footnote marked thus **** and **.

Table C(2) - Existing treatment facilities - Municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	23	23	52,200
Secondary	4	4	17,300
No treatment	24	0	56,300

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

Table D(2) - Existing treatment facilities - Industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products ---------	7	2	1	4
Petroleum -------	8	8	0	0
Miscellaneous ----	4	2	1	1
Mining industries -	1	0	1	0
Total	20	12	3	5

* Industries having separate outlets and discharging wastes directly to watercourse.

Table $E_{(2)}$ - Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	27	9	8	10	13	3	11
Industrial	12	8	2	2	10	0	2

Table $F_{(2)}$ - Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (In terms of equivalent number of people)
1946	0	- - - -	0	- - - -
1947	0	- - - -	1	Unknown
1948	0	- - - -	1	Unknown
1949	1	500	2	13,200

Table G(2) - Requirements for municipal and industrial waste treatment plants

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	14	29,000	2
Enlargement or additions to existing plant	4	19,200	2
Replace existing plant	3	3,300	0
No project required	11	39,400	7
Undetermined	19*	34,900	9**

* Includes 8 municipalities where no treatment facilities now exist and need for treatment not determined, and 1 existing plant whose requirements have not yet been determined. ** Includes one industry not now having treatment and one industry having inadequate treatment for which requirements have not yet been determined.

Table H(2) - Status of treatment works project to abate pollution - July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	10	3
Abatement ordered*	0	0
Plans under preparation	1	0
Final plans approved	0	0
Construction awaiting financing	0	0
Under construction	4	0
Status undetermined	6	1

(Footnote continued)

(Footnote for Table $H_{(2)}$)

* Formal orders to municipalities and industries for abatement of pollution have received little use as an administrative procedure in the Yellowstone Sub-Basin. Instead, State water pollution control agencies have preferred to use a cooperative approach, working closely with polluters in an attempt to secure abatement of pollution without exercise of police power. Formal orders have in general been used only in recalcitrant cases where the cooperative approach has not been successful. Acceleration of abatement activities in this Sub-Basin may conceivably increase the use of formal orders as an administrative expedient.

Table I$_{(2)}$ - Project list - Municipalities and industries requiring improvements for abatement of pollution - July 1, 1950

Name	Population served	Project requirements	Remarks
Montana:			
Gardiner ------	850	Enlarge existing plant	- - - -
Jardine Mining Co. -----------	Not known	Needs undetermined	- - - -
Livingston	6, 700	Needs undetermined	- - - -
Big Timber ---	1, 112	Needs undetermined	- - - -
Columbus ------	949	Needs undetermined	- - - -
Laurel --------	4, 000	New plant needed	Under construction
Bridger -------	700	Replace existing plant	- - - -
Billings			
Gr. Western Sugar Co. -----	400, 000*	Needs undetermined	- - - -
Pierce Packing Co. -------	411*	Needs undetermined	- - - -
Midland Packing Co. -------	51*	Needs undetermined	- - - -
Hardin --------	1, 800	Needs undetermined	- - - -
Holly Sugar Co. -	Not known	Needs undetermined	- - - -
Lodgegrass ----	840	Needs undetermined	- - - -
Crow Agency --	800	Needs undetermined	- - - -
Hysham -------	275	Needs undetermined	- - - -
Forsythe ------	2, 000	Needs undetermined	- - - -
Lame Deer ----	50	Needs undetermined	- - - -
Fort Keogh ----	75	Needs undetermined	- - - -

(Table I$_{(2)}$ - continued)

Table $I_{(2)}$ - (continued)

Name	Population served	Project requirements	Remarks
Montana:			
Miles City -----	7,200	Needs undetermined	- - - -
C. M., St. Paul & P. R. R. Shops-	Not known	New plant needed	- - - -
Broadus -------	500	Needs undetermined	- - - -
Terry ---------	500	Needs undetermined	- - - -
Baker ---------	1,600	New plant needed	- - - -
Glendive -------	5,060	Needs undetermined	- - - -
N. P. R. R. Shops	Not known	Needs undetermined	- - - -
Sidney ---------	3,000	Needs undetermined	- - - -
Holly Sugar Co. -	Not known	Needs undetermined	- - - -
Wyoming:			
Lake, Yellowstone Park -----	1,000	Replace existing plant	- - - -
Canyon, Yellowstone Park -----	1,550	Replace existing plant	- - - -
Lander --------	4,000	New plant needed	- - - -
Dubois --------	150	New plant needed	- - - -
Shoshone Indian Reservation Headquarters---	325	Enlarge existing plant	- - - -
Riverton -------	4,500	New plant needed	- - - -
Thermopolis ---	4,000	New plant needed	- - - -

(Table $I_{(2)}$ - continued)

Table $I_{(2)}$ - (continued)

Name	Population served	Project requirements	Remarks
Wyoming:			
Empire State Ref. ----------	Not known	Enlarge existing plant	- - - -
Hot Springs State Park ----	250	New plant needed	Planning initiated
Worland ------	4, 000	New plant needed	- - - -
Wyo. Inst. for Boys ------	200	New plant needed	Under construction
Holly Sugar Refinery ------	200, 000*	Needs undetermined	- - - -
Basin --------	1, 500	New plant needed	- - - -
Cody ---------	3, 500	New plant needed	- - - -
Husky Refining Co. ----------	Not known	New plant needed	- - - -
Powell -------	1, 200	New plant needed	- - - -
Cowley -------	300	Needs undetermined	- - - -
Lovell --------	3, 000	Needs undetermined	- - - -
Husky Refining Co.------------	Not known	Enlarge existing plant	- - - -
Gr. Western Sugar Co. ------	Not known	Needs undetermined	- - - -
Sheridan -------	15, 000	Enlarge existing plant	- - - -
State Home for Girls ---------	75	New plant needed	Under construction
Birney --------	50	Needs undetermined	- - - -
Midwest -------	700	Needs undetermined	- - - -
Buffalo --------	3, 000	Enlarge existing plant	- - - -
State Old Soldiers' Home	60	New plant needed	Under construction

* Strength of industrial waste measured in terms of equivalent number of people.

MISSOURI RIVER MAIN STEM AND MINOR TRIBUTARIES FROM FT. PECK RESERVOIR TO SPRING CREEK SUB-BASIN

Physical Description

Geography - This Sub-Basin, with a maximum width of 305 miles and a length of 430 miles, occupies parts of the States of North Dakota, South Dakota, Montana, and Wyoming. The area encompasses approximately 48,500 square miles, which represents 9 percent of the Missouri Basin. For administrative reasons a portion of North Dakota not lying within the Missouri Basin Drainage Area is also included as a part of this Sub-Basin. This section is known as the Souris River-Devils Lake Area. The natural boundaries are formed by Hudson Bay Drainage Basin to the north, the James River Watershed to the east, the Grand River Drainage Area to the south, and the Yellowstone and Upper Missouri Drainage Basins to the west.

Topography - Approximately 580 river miles of the main stem of the Missouri River lie within the bounds of this Sub-Basin. Five principal tributary streams carry runoff to the main stem of the Missouri River. These include the Poplar River of Montana which heads in Canada, the Little Missouri which rises in the northeastern corner of Wyoming, the Knife River lying wholly within the State of North Dakota, the Heart River, also within the State of North Dakota, and the Cannonball River which drains portions of both North and South Dakota. In the Souris-Devils Lake Area the Souris River provides the major drainage system. It flows southward from Canada into the United States and again turns northward back into Canada. About 220 miles of the Souris River Valley is in the State of North Dakota. To the east of the Souris Drainage Basin lies the Devils Lake Region, which has no well defined drainage system and is better described as a land-locked area.

Most of the Sub-Basin is in the glaciated Missouri Plateau and has extremely deep soils. The elevation of the region ranges from 2,000 feet at its extreme western boundary to slightly more than 1,500 feet at its southeastern terminus. The topography is for the most part that of a flat plain with numerous dunelike hills. Much of the area lying north of the Missouri River and between the Missouri and the James River has no well developed pattern of drainage, and during periods of heavy precipitation is dotted with lakes and ponds. This topography is known locally as "pimpledimple land," and is exemplified by the existence of the Devils Lakes of North Dakota which do not have any natural drainage. There are no forests and tree growth is limited largely to the flood plain along the main stem of the Missouri River.

Climate - The climate of the region is very rigorous. The mean annual temperature is 43° F., with recorded extremes of -42° and 118°. Humidity is relatively low throughout the entire Sub-Basin. Rainfall varies from 12 inches annually in the northwestern section to about 20 inches at its southeastern terminus. Large expanses of level land and absorptive soils hold runoff to an absolute minimum.

Hydrology - The tributaries lying within the Sub-Basin do not contribute large quantities of water to the main stem. The Poplar River drains 3,270 miles of territory and has a mean annual flow of about 100 second-feet. The Little Missouri River is 560 miles in length and drains an area of 9,500 square miles; its annual mean flow is approximately 625 second-feet. The Knife River is 165 miles in length and drains an area of about 2,625 square miles. It has an annual mean flow of approximately 190 second-feet. The Heart River, 241 miles in length and draining an area of 3,400 square miles, has a mean annual flow of about 250 second-feet. The Cannonball River is approximately 300 miles in length, drains an area of about 4,300 square miles, and has a mean annual flow of about 215 second-feet. It will be noted that the mean annual contribution from the 5 tributaries amounts to something less than 1,400 c.f.s. The flow in these tributaries is quite erratic, and during much of the year the stream beds are dry. The flows in the Souris River are also quite small and erratic.

Economic Development - About 75 percent of the population residing in the Sub-Basin derive their living from agricultural pursuits, while the remaining 25 percent are engaged in industry and service operations closely allied with an agricultural economy. Dry farming in the past has dominated the region; however, upon completion of the proposed Missouri Basin Development Program, more than a million acres of newly irrigated land will be added to the acreage under crop in this Sub-Basin.

Uses of Water Resources - There perhaps is no other place in the Missouri Drainage Basin where the potential value of the land is greater, and it awaits only the addition of sufficient water to realize these potentialities. Many of the municipalities have been definitely limited in growth because they lack adequate water for both domestic consumption and for the removal of sanitary and industrial wastes. Water therefore is extremely valuable in this Sub-Basin. The poor chemical quality and general absence of ground water in sufficient quantities has prevented ground water developments for other than very localized uses. Surface water resources are virtually nonexistent except along the Missouri River. The disposal of sanitary and industrial wastes has created a difficult problem because the limited flow in most of the streams is not sufficient to assimilate the waste.

Pollution Data

A summation of the data on the sources and amount of pollution, together with the kind and amount of treatment installed and still needed, is presented in tables $A_{(3)}$ to $I_{(3)}$.

Table $A_{(3)}$ indicates that approximately 26 percent of the population equivalent units of B.O.D. are removed by treatment now installed. Included with municipal wastes is a population equivalent of 9,350 derived from industrial wastes being discharged into municipal sewer systems. A further analysis of table $A_{(3)}$ indicates that towns, although numerous, are relatively small in population, and that the industrial waste component of the municipal pollution is only approximately 10 percent.

There are no industries, according to present data, which are discharging directly to watercourses of the Sub-Basin.

Table $C_{(3)}$ shows that 78 percent of the municipalities have some type of treatment facilities. It also shows that 84 percent of the plants installed provide primary treatment only, and that 62 percent of the connected urban population is served by sewage treatment.

Table $E_{(3)}$ indicates that the design capacities of the installed municipal treatment plants are satisfactory at about 66 percent of the installations, while operation of the installed plants is considered satisfactory at 75 percent of the plants.

Table $F_{(3)}$ indicates that 11 new municipal sewage treatment plants were constructed in the Sub-Basin during the years 1946 through 1949. There were no industrial waste treatment plants constructed during this period.

Table $G_{(3)}$ indicates a need for new sewage treatment plants or improvements to existing facilities in 33 municipalities, a betterment for approximately 73 percent of the Sub-Basin's connected population. Table $H_{(3)}$ shows that some action is being taken in 9 of the 33 municipalities for which requirements have been determined. The towns where improvements or new plants are needed are listed in Table $I_{(3)}$. The requirements of some of the cities or towns listed may be changed, pending further investigation and completion of studies now in process.

The picture of pollution and pollution abatement in this Sub-Basin is subject to modification because of the pending Missouri River Development Program which, if carried to completion, will greatly affect the water resources of this area. It may be expected that there will also be alterations in the economy of the Basin which in turn will be reflected by a greater population in both urban and rural areas and a greater amount of industry, particularly that type associated with the processing of farm produce.

Pollution abatement in this Sub-Basin is of considerable local importance. The scarcity of water at the present time makes it imperative that the available water be used most advantageously. The fact that almost 80 percent of the municipalities have treatment facilities reflects the importance of sewage pollution abatement.

Table $A_{(3)}$ - Sources of pollution - Municipal

Municipalities*	Sources of pollution (In number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (In terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	67	106,300***	86,400
Having population data available (Data on pollution load to watercourse incomplete or not available)	5	2,000	Not applicable
Total	72	108,300	- - - -

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers, or other population centers; sanitary sewage wastes discharged by industry directly to watercourse.

** Includes industrial wastes discharged into municipal sewerage systems.

*** Data do not include industrial waste of 9,400 population equivalent discharging to municipal sewers.

Table $B_{(3)}$ - Sources of pollution - Industrial*

Industries	Sources of pollution (In number of plants)	Amount of pollution discharged to watercourse (In terms of equivalent number of people)
Producing organic wastes	0	- - - -
Producing organic wastes	0	- - - -
Producing inorganic wastes	0	- - - -
Producing wastes of undetermined type	0	- - - -
Total	0	- - - -

* Industries having separate outlets and discharging wastes directly to watercourse.

Table C(3) - Existing treatment facilities - Municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	47	47**	40,700
Secondary	9	9	26,400
No treatment	16	0	41,200

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

** Includes 6 ponds classified as primary treatment.

Table D(3) - Existing treatment facilities - Industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
	No industries			

* Industries having separate outlets and discharging wastes directly to watercourse.

Table $E_{(3)}$ - Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satis-factory	Unsatis-factory	Unde-termined	Satis-factory	Unsatis-factory	Unde-termined
Municipal	56	37*	13	6	42	3	11
Industrial	0	0	0	0	0	0	0

* Includes 4 treatment plants where existing units have adequate capacity but additional units are needed to provide a higher degree of treatment. These needs are reflected in table $G_{(3)}$.

Table $F_{(3)}$ - Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (In terms of equivalent number of people)
1946	2	2,500	0	- - - -
1947	3	4,800	0	- - - -
1948	4	3,100	0	- - - -
1949	2	875	0	- - - -

Table $G_{(3)}$ - Requirements for municipal and industrial waste treatment plants

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	28*	58,100	0
Enlargement or additions to existing plant	4	17,900	0
Replace existing plant	1	1,900	0
No project required	33	28,000	0
Undetermined	6	2,400	0

* Includes 12 existing facilities which due to local conditions have been classified as needing new plants rather than replacements.

Table $H_{(3)}$ - Status of treatment works project to abate pollution - July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	24	0
Abatement ordered*	0	0
Plans under preparation	1	0
Final plans approved	1	0
Construction awaiting financing	0	0
Under construction	4	0
Status undetermined	3	0

(Footnote continued)

(Footnote for Table $H_{(3)}$)

* Formal orders to municipalities and industries for abatement of pollution have received little use as an administrative procedure in the Missouri River Main Stem and Tributaries, Fort Peck to Spring Creek Sub-Basin. Instead, State water pollution control agencies have preferred to use a cooperative approach, working closely with polluters, in an attempt to secure abatement without the exercise of police power. Formal orders in general have been used only in recalcitrant cases where the cooperative approach has not been successful. Acceleration of abatement activities in this Sub-Basin may conceivably increase the use of formal orders as an administrative expedient.

Table I(3) - Project list - Municipalities and industries requiring improvements for abatement of pollution - July 1, 1950

Name	Population served	Project requirements	Remarks
Montana:			
Wolf Point	1,500	New plant needed	- - - -
Poplar	1,900	Replace existing plant	- - - -
Plentywood	1,200	New plant needed	- - - -
Medicine Lake	350	Needs undetermined	- - - -
Wibaux	500	Needs undetermined	- - - -
North Dakota:			
Williston	6,000	New plant needed	- - - -
Wild Rose	472	Needs undetermined	- - - -
Tioga	300	New plant needed	Under construction
Stanley	1,200	Enlarge existing plant	- - - -
Marmarth	700	New plant needed	- - - -
Beach	1,350	New plant needed	- - - -
Arnegard	200	New plant needed	Under construction
Riverton	2,000	New plant needed	- - - -
Beulah	1,000	New plant needed	- - - -
Hazen	700	Enlarge existing plant	- - - -
Washburn	1,200	New plant needed	- - - -
McClusky	500	Needs undetermined	- - - -

Table I(3) - (Continued)

Table I(3) - (Continued)

Name	Population served	Project requirements	Remarks
Goodrich	350	Needs undetermined	- - - -
Bismarck	15,000	New plant needed	- - - -
Belfield	1,000	Enlarge existing plant	- - - -
Mandan	4,000	New plant needed	- - - -
Fort Lincoln	200	New plant needed	Planning initiated
New England	900	New plant needed	- - - -
Mott	1,200	New plant needed	- - - -
Crosby	2,000	New plant needed	- - - -
Columbus	450	New plant needed	Final plans approved
Bowbells	200	Needs undetermined	- - - -
Kenmare	1,700	New plant needed	- - - -
Minot	15,000	Enlarge existing plant	Under construction
Velva	1,500	New plant needed	- - - -
Drake	700	New plant needed	- - - -
Tower	1,000	New plant needed	- - - -
Rolla	1,200	New plant needed	- - - -
Bottineau	2,000	New plant needed	Under construction
Mohall	800	New plant needed	- - - -

Table I(3) - (Continued)

Table $I_{(3)}$ - (Continued)

Name	Population served	Project requirements	Remarks
West Hope ----	400	New plant needed	- - - -
Condo --- ----	1,500	New plant needed	- - - -
Devils Lake ---	7,000	New plant needed	- - - -
Lakota -------	1,100	New plant needed	- - - -

MISSOURI RIVER MAIN STEM AND MINOR TRIBUTARIES FROM SPRING CREEK TO JAMES RIVER SUB-BASIN

Physical Description

Geography - The Sub-Basin has a maximum width of approximately 280 miles and a length of 450 miles, and occupies parts of the States of Montana, North Dakota, Wyoming, South Dakota, and Nebraska. The area totals approximately 76,300 square miles, which represents 14 percent of the Missouri Basin. The natural boundaries are formed by the Cannonball River Watershed to the north, the James River Sub-Basin to the east, the Platte River System to the south, and the Yellowstone River Drainage Area to the west.

Topography - There are 6 important tributaries to the Missouri River within this Sub-Basin, besides 441 miles of the main stem of the Missouri River. The tributaries include the Grand River, the Moreau River, the Cheyenne and Belle Fourche System, the Bad River, the White River, and the Niobrara River. With the exception of the Niobrara, the flow characteristics of these streams are similar; likely to be flooded in the months of March, April, May and June and dwindle until they are often dry in their upper reaches in the late summer and fall. The Niobrara, however, is a fairly constant flowing stream and contributes as much water to the main stem of the Missouri River as the other tributaries together.

Other topographic features of this Sub-Basin are such that it might be termed a high plains region. The outstanding features, however, are not those of a plains region. These are the Black Hills Uplift, the Nebraska Sand Hills, and the South Dakota Badlands.

Climate - The climatological characteristics are those of a semiarid region. The mean annual temperature is 45° F., and rainfall varies between 10 and 15 inches per year. This area has been aptly termed the "north side of the Great Plains dust bowl."

Economic Development - The population density of this Sub-Basin is very low, and much of the region is devoted to ranching and grazing operations. The only mineral wealth of mention is to be found in the Black Hills region of western South Dakota and eastern Wyoming. In this Black Hills region gold, silver, lead, zinc, and oil are being produced in quantity. Ground waters over all the Sub-Basin, with the exception of the area along the Niobrara, are hard to find, and when located frequently contain large quantities of mineral matter. Surface waters therefore are at a premium for municipal and domestic use and for irrigation and stock watering purposes. The Gavin's Point, Fort Randall, Big Bend and Oahe Dams are being and will be constructed on the main stem of the Missouri River which lies within this Sub-Basin.

Pollution Data

The summary of data on sources and amount of pollution contributed to the waterways of the Sub-Basin, together with the kind of treatment presently installed and needed in the future, is shown in table $A_{(4)}$ through $I_{(4)}$.

Table A(4) indicates that approximately 40 percent of the B.O.D. in terms of population equivalent units is removed by treatment from the waste contributed by combined domestic and industrial sources. Industrial waste contributed to municipal sewer systems by use of available although admittedly inadequate data is estimated to be equivalent to that produced by not less than 3,627 persons, and is shown as a footnote to table $A_{(4)}$.

Table $B_{(4)}$ shows that most of the sources of industrial pollution are contributing both inorganic and organic wastes.

Table C(4) indicates that approximately 67 percent of the municipalities having sanitary sewers also provide sewage treatment, and 62 percent of the population connected to sewers is served by such treatment plants.

Table D(4) indicates that oil refineries are the major source of industrial waste in this area. In addition, there is a considerable amount of waste originating from the separation of gold and other metals from the ore mined in the Black Hills region of South Dakota. These wastes consist principally of cyanides and rock flour, which are detrimental to the receiving stream for a great distance. In addition to the industries listed in Table $D_{(4)}$, there is an undetermined amount of waste from oil fields located in the eastern section of Wyoming. There are also a number of sawmills located along the western slope of the Black Hills region. It has not been determined to what extent the sawdust may be affecting watercourses in the immediate vicinity of these installations.

Table E(4) indicates that 54 percent of the municipal waste treatment plants have adequate capacity and that about 70 percent of them are being operated satisfactorily. This latter figure reflects a rather high degree of operational efficiency.

Table F(4) indicates that 5 new municipal sewage treatment plants were constructed during the years 1946 through 1949. No industrial waste treatment plants were constructed during this period.

Table G(4) indicates that there is need for 32 new municipal waste treatment plants, replacement of 2 plants, and additions or enlargements to 15 other existing plants. Thirty-four percent of the connected population is at the present time being provided with adequate sewage treatment facilities.

Table H(4) indicates that about 10 percent of the municipalities have taken some action to meet the municipal requirements as shown in table G(4).

Table I(4) is a listing of the individual municipal and industrial plant waste needs. In many instances the requirement may be changed when investigations have been completed.

The semiarid condition of this Sub-Basin, together with the lack of good ground water sources, makes it necessary that sewage treatment facilities be provided at most of the municipalities in order to avoid local nuisance conditions, and to reclaim the water so that it may be used for other purposes.

Table $A_{(4)}$ - Sources of pollution - Municipal

Municipalities*	Sources of pollution (In number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (In terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	78	126,400***	78,700
Having population data available (Data on pollution load to watercourse incomplete or not available)	0	- - - -	- - - -
Total	78	126,400	78,700

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers, or other population centers; sanitary sewage wastes discharged by industry directly to watercourse.

** Includes industrial wastes discharged into municipal sewerage systems.

*** Data do not include industrial waste of 3,600 population equivalent discharging to municipal sewers.

Table $B_{(4)}$ - Sources of pollution - Industrial*

Industries	Sources of pollution (In number of plants)	Amount of pollution discharged to watercourse (In terms of equivalent number of people)
Producing organic wastes	1**	125,000
Producing organic wastes	8***	Undetermined
Producing inorganic wastes	9	Not applicable
Producing wastes of undetermined type	0	- - - -
Total	10****	- - - -

* Industries having separate outlets and discharging wastes directly to watercourse.

** Seasonal waste.

*** Includes 8 plants also producing inorganic wastes.

**** Total adjusted to correct for duplication noted by footnote marked***.

Table $C_{(4)}$ - Existing treatment facilities - Municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary **	31	31	30,200
Secondary	21	21	48,200
No treatment	26	- - - -	48,000

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

** Includes those municipalities which pond wastes and have no other structures.

Table $D_{(4)}$ - Existing treatment facilities - Industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products ----------	1	1	0	0
Products of petroleum and coal -----	8	5	3	0
Mining industries --	1	0	1	0
Total	10	6	4	0

* Industries having separate outlets and discharging wastes directly to watercourse.

Table $E_{(4)}$ - Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	52	28*	24	0	36	12	4
Industrial	6	4**	2	0	1	0	5

* Includes 1 treatment plant where existing units have adequate capacity, but additional units are needed to provide a higher degree of treatment. These needs are reflected in table $G_{(4)}$. ** Includes 3 industrial waste treatment plants where existing units have adequate capacity, but additional units are needed to provide a higher degree of treatment. These needs are reflected in table $G_{(4)}$.

Table $F_{(4)}$ - Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (In terms of equivalent number of people)
1946	0	- - - -	0	- - - -
1947	1	350	0	- - - -
1948	0	- - - -	0	- - - -
1949	4	12,800	0	- - - -

Table $G_{(4)}$ - Requirements for municipal and industrial waste treatment plants

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	32*	45,200	0
Enlargement or additions to existing plant	15	31,700	5
Replace existing plant	2	5,700	0
No project required	29**	43,800	1
Undetermined	0	- - - -	4***

* Includes 8 existing facilities which due to local conditions have been classified as needing new plants rather than replacements. ** Includes 2 municipalities not now having treatment. *** Four industrial plants have no treatment and needs have not been determined.

Table $H_{(4)}$ - Status of treatment works project to abate pollution - July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	33	4
Abatement ordered*	0	0
Plans under preparation	0	0
Final plans approved	2	0
Construction awaiting financing	0	0
Under construction	3	0
Status undetermined	11	1

(Footnote continued)

(Footnote for Table $H_{(4)}$)

* Formal orders to municipalities and industries for abatement of pollution have received little use as an administrative procedure in this Sub-Basin. Instead, State water pollution control agencies have preferred to use a cooperative approach, working closely with polluters in an attempt to secure abatement without exercise of police power. Formal orders have in general been used only in recalcitrant cases where the cooperative approach has not been successful. Acceleration of abatement activities in this Sub-Basin may conceivably increase the use of formal orders as an administrative expedient.

Table $I_{(4)}$ - Project list - Municipalities and industries requiring improvements for abatement of pollution - July 1, 1950

Name	Population served	Project requirements	Remarks
Nebraska:			
Crawford -----	1,700	Enlarge existing plant	- - - -
Chadron ------	4,500	Replace existing plant	- - - -
Spencer-------	475	New plant needed	- - - -
Lynch --------	350	New plant needed	- - - -
Hay Springs---	600	Enlarge existing plant	- - - -
Rushville -----	1,000	Enlarge existing plant	- - - -
Gordon -------	1,500	Enlarge existing plant	- - - -
Valentine -----	2,000	New plant needed	- - - -
Long Pine-----	250	Enlarge exist ing plant	- - - -
Niobrara------	1,150	Replace existing plant	- - - -
Bloomfield	1,200	Enlarge existing plant	- - - -
North Dakota:			
Bowman ------	890	Enlarge existing plant	- - - -
Heffinger -----	1,600	New plant needed	- - - -
South Dakota:			
Buffalo -------	573	New plant needed	Final plans approved
Eureka -------	1,200	New plant needed	- - - -
Lemmon	1,000	New plant needed	- - - -

Table $I_{(4)}$ - (Continued)

Table $I_{(4)}$ - (Continued)

Name	Population served	Project requirements	Remarks
Mobridge -----	3,000	New plant needed	- - - -
Bowdle -------	700	Enlarge existing plant	- - - -
Cheyenne Agency	1,200	New plant needed	- - - -
Edgemont -----	900	New plant needed	- - - -
Rapid City ----	20,000	Enlarge existing plant	Under construction
Belle Fourche -	2,500	New plant needed	- - - -
U & I Sugar Refinery-----	125,000	Enlarge existing plant	- - - -
Newell--------	350	New plant needed	- - - -
Faith---------	400	Enlarge existing plant	- - - -
Hoven --------	370	New plant needed	Under construction
Onida---------	400	Enlarge existing plant	- - - -
Pierre--------	4,322	New plant needed	- - - -
Ft. Pierre----	764	New plant needed	- - - -
Kadoka -------	400	New plant needed	- - - -
Highmore -----	700	New plant needed	- - - -
Presho -------	400	New plant needed	- - - -
Ft. Thompson -	500	New plant needed	- - - -
Chamberlain --	1,626	New plant needed	- - - -

Table $I_{(4)}$ - (Continued)

Table $I_{(4)}$ - (Continued)

Name	Population served	Project requirements	Remarks
Kimball-------	800	New plant needed	- - - -
Platte --------	1,000	New plant needed	Final plans approved
Geddes -------	600	New plant needed	- - - -
Lake Andes ---	800	New plant needed	- - - -
Wagner-------	1,000	Enlarge existing plant	- - - -
Avon ---------	500	New plant needed	- - - -
Gregory ------	1,200	Enlarge existing plant	- - - -
Tyndall-------	700	New plant needed	- - - -
Springfield----	667	New plant needed	- - - -
Yankton-------	6,798	New plant needed	- - - -
Wyoming:			
Upton---------	600	Enlarge existing plant	- - - -
Two Oil Fields	Not known	Needs undetermined	- - - -
Osage Oil Refinery	Not known	Needs undetermined	- - - -
Newcastle-----	4,500	New plant needed	Under construction
3 Oil Refineries	Not known	Enlarge existing plant	- - - -
Gillette-------	3,200	New plant needed	- - - -
Moorcroft-----	300	Enlarge existing plant	- - - -

Table $I_{(4)}$ - (Continued)

Table $I_{(4)}$ - (Continued)

Name	Population served	Project requirements	Remarks
Sundance------	1,200	New plant needed	- - - -
Crook Co. Oil Ref. -----	Not known	Enlarge existing plant	- - - -
Manville------	240	New plant needed	- - - -
Lusk C & H Oil Refinery-----	Not known	Needs undetermined	- - - -

JAMES RIVER SUB-BASIN

Physical Description

Geography - The Sub-Basin, with a maximum width of approximately 100 miles and a length of 370 miles, occupies parts of the States of North and South Dakota. The area encompasses approximately 22,100 square miles and represents 4 percent of the Missouri Basin. The natural boundaries are formed by the Sheyenne River Watershed to the north and northeast, the Big Sioux River Sub-Basin to the east, and the drainage area of the Main Stem of the Missouri River to the south and west.

Topography - The James River has no large tributaries. It is approximately 700 miles in length, rising in central North Dakota and flowing almost due southward to join the Missouri River just east of Yankton, S. Dak. The course of the James River is a tortuous one. It has an average stream gradient below Jamestown, N. Dak., of only 0.3 of a foot per mile. Much of the land lying within this Sub-Basin has little or no drainage pattern, and runoff is very slight. The average flow of the James River at its confluence with the Missouri is 250 second-feet.

Climate - Climatic conditions are rather severe; temperatures range from a -42° F. to 115° F. Rainfall is limited and ranges between 18 and 25 inches per year.

Economic Development - The James River Sub-Basin is covered with soil of comparatively high fertility, and heretofore agriculture has been the basis of the local economy. The lack of water has greatly retarded the development of both agriculture and industry up to the present time. The farm population has decreased the last 40 years; however, this decrease has been offset by a comparable increase in the urban areas. As a result, the cities of Jamestown, N. Dak.; Aberdeen, Huron, and Mitchell, S. Dak.; have grown rapidly in size and are centers of an expanding food processing industry, principally that of meat packing.

It may be expected that there will be a growth of both the rural and urban population within the James River Sub-Basin as soon as the Missouri River Development Plan has been placed in effect. It is planned to bring under irrigation nearly one million acres of land lying west of the James River between Aberdeen and Huron, S. Dak., thus greatly increasing its productivity.

There are no reclamation projects at present on the James River, however, according to the Missouri River Development Plan water from the Upper Missouri River will be diverted through a system of canals to the James for various water uses including domestic, irrigation, sanitation, and fish and wildlife conservation. The present river flows are very erratic and undependable for the before-mentioned uses.

Pollution Data

The summary of sources and amount of pollution in the James River Sub-Basin, together with a tabulation of existing facilities and future needs, are illustrated in tables $A_{(5)}$ through $I_{(5)}$.

Table $A_{(5)}$ indicates that approximately 34,200 population equivalent units (second footnote table $A_{(5)}$) from industrial sources are contributed to municipal sewers compared to 88,100 units of domestic waste. Existing treatment facilities remove about 65 percent of the biochemical oxygen demand prior to the entrance of the waste into streams.

Table $B_{(5)}$ indicates that there are only four small industrial plants discharging waste directly to watercourses of the Sub-Basin, three of which produce organic wastes.

Table $C_{(5)}$ indicates that 61 percent of the municipalities having sewer systems are equipped with treatment facilities. In terms of sewered population, 85 percent is serviced by treatment plants.

Table D(5) indicates that one industry is providing treatment for its wastes.

Table $E_{(5)}$ indicates that about 48 percent of the existing municipal waste treatment plants have adequate capacity and that operation is satisfactory at 75 percent of the existing installations.

Table $F_{(5)}$ shows that 5 new municipal waste treatment works and one new industrial waste treatment plant was constructed in the Sub-Basin during the years 1946 through 1949.

Table $G_{(5)}$ indicates that there is a need for 20 new municipal waste treatment plants and improvements at 13 existing installations. The table also indicates that, in spite of the high degree of treatment already provided, only 8 percent of the sewered domestic population is supplied with adequate treatment facilities.

Table $H_{(5)}$ indicates that 9 municipal projects have been activated, representing 27 percent of the number of municipal projects required as noted in table $G_{(5)}$.

Table $I_{(5)}$ lists the name and location of municipalities and industries for which projects are needed. The requirements listed are subject to change in those instances where they are based on incomplete information.

The limited supply of water in the James Sub-Basin has made it necessary for most of the municipalities to provide a high degree of treatment to prevent local nuisance conditions. Examination of the data indicates that a greater degree of treatment than presently exists must be supplied if streams are to be maintained in a sanitary condition.

Water use in the James River heretofore has been primarily for livestock watering, game fishing, recreation, and bathing. Very minor usage has occurred for domestic supply or for irrigation. Low and erratic flows exclude these uses. The river is used quite extensively for carrying domestic and industrial wastes from urban areas. The flows in the James River will be markedly increased when the diversions from the Missouri River have been made as planned in the Missouri River Basin Development Program.

Table $A_{(5)}$ - Sources of pollution - Municipal

Municipalities*	Sources of pollution (In number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (In terms of equivalent number of people) **
Having data on pollution load discharged to watercourse	44	88,100***	42,400
Having population data available (Data on pollution load to watercourse incomplete or not available)	0	- - - -	- - - -
Total	44	88,100	42,000

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers, or other population centers; sanitary sewage wastes discharged by industry directly to watercourse.

** Includes industrial wastes discharged into municipal sewerage systems.

*** Data do not include industrial waste of 34,200 population equivalent discharging to municipal sewers.

Table $B_{(5)}$ - Sources of pollution - Industrial*

Industries	Sources of pollution (In number of plants)	Amount of pollution discharged to watercourse (In terms of equivalent number of people)
Producing organic wastes	3	2, 300
Producing organic wastes	0	- - - -
Producing inorganic wastes	1	Not applicable
Producing wastes of undetermined type	0	- - - -
Total	4	- - - -

* Industries having separate outlets and discharging wastes directly to watercourse.

Table $C_{(5)}$ - Existing treatment facilities - Municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary**	13	13	8,200
Secondary	14	14	66,600
No treatment	17	- - - -	13,300

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

** Includes 3 municipalities which pond wastes.

Table $D_{(5)}$ - Existing treatment facilities - Industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products----------	3	1	2	0
Miscellaneous -----	1	0	1	0
Total	4	1	3	0

* Industries having separate outlets and discharging wastes directly to watercourse.

Table $E_{(5)}$ - Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to: Capacity: Satisfactory	Capacity: Unsatisfactory	Capacity: Undetermined	Operation: Satisfactory	Operation: Unsatisfactory	Operation: Undetermined
Municipal	27	13*	14	0	20	7	0
Industrial	1	1	0	0	1	0	0

* Includes 2 treatment plants where existing units have adequate capacity, but additional units are needed to provide a higher degree of treatment. These needs are reflected in table $G_{(5)}$.

Table $F_{(5)}$ - Progress in pollution abatement

Year	Municipal: Plants completed	Municipal: Design population	Industrial: Plants completed	Industrial: Amount of waste treated (In terms of equivalent number of people)
1946	1	1,000	0	- - - -
1947	0	- - - -	0	- - - -
1948	0	- - - -	0	- - - -
1949	4	36,100	1	500

Table $G_{(5)}$ - Requirements for municipal and industrial waste treatment plants

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	20*	25,100	2
Enlargement or additions to existing plant	13	55,500	0
Replace existing plant	0	- - - -	0
No project required	11	7,500	1
Undetermined	0	- - - -	1

* Includes 3 existing facilities which due to local conditions have been classified as needing new plants rather than replacements.

Table $H_{(5)}$ - Status of treatment works project to abate pollution - July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	18	1
Abatement ordered *	0	0
Plans under preparation	5	1
Final plans approved	0	0
Construction awaiting financing	0	0
Under construction	4	0
Status undetermined	6	0

(Footnote continued)

(Footnote for Table $H_{(5)}$)

* Formal orders to municipalities and industries for abatement of pollution have received little use as an administrative procedure in this Sub-Basin. Instead, State water pollution control agencies have preferred to use a cooperative approach working closely with polluters in an attempt to secure abatement without exercise of police power. Formal orders have in general been used only in recalcitrant cases where the cooperative approach has not been successful. Acceleration of abatement activities in this Sub-Basin may conceivably increase the use of formal abatement orders as an administrative expedient.

Table $I_{(5)}$ - Project list - Municipalities and industries requiring improvements for abatement of pollution - July 1, 1950

Name	Population served	Project requirements	Remarks
North Dakota:			
Fessenden	1,000	New plant needed	- - - -
New Rockford	2,000	New plant needed	- - - -
Carrington	2,000	New plant needed	- - - -
Sykeston	300	New plant needed	- - - -
Jamestown	10,000	New plant needed	Planning initiated
Slaughter plant	300*	New plant needed	- - - -
Railroad yards	100*	Needs undetermined	- - - -
LaMoure	1,500	New plant needed	- - - -
Oakes	2,000	New plant needed	- - - -
Ellendale	1,500	Enlarge existing plant	- - - -
Edgeley	1,000	Enlarge existing plant	- - - -
South Dakota:			
Frederick	400	New plant needed	- - - -
Aberdeen	23,000	Enlarge existing plant	Under construction
Bristol	60	New plant needed	Under construction
Sugar Creek Creamery Company	1,040*	New plant needed	Planning initiated
Groton	750	New plant needed	Planning initiated

Table $I_{(5)}$ - (Continued)

Table $I_{(5)}$ - (Continued)

Name	Population served	Project requirements	Remarks
Roscoe	500	New plant needed	Planning initiated
Ipswich	950	New plant needed	Planning initiated
Faulkton	600	New plant needed	- - - -
Miller	1,400	Enlarge existing plant	Under construction
St. Lawrence	180	Enlarge existing plant	- - - -
Redfield	2,500	Enlarge existing plant	Planning initiated
School for Feeble Minded	850	Enlarge existing plant	Under construction
Doland	500	New plant needed	- - - -
Huron	12,000	Enlarge existing plant	- - - -
Wessington	300	New plant needed	- - - -
Wolsey	400	New plant needed	- - - -
Iroquois	330	Enlarge existing plant	- - - -
Bryant	500	New plant needed	- - - -
Artesian	400	New plant needed	- - - -
Mitchell	10,000	Enlarge existing plant	- - - -
Mt. Vernon	400	New plant needed	- - - -
Alexandria	600	Enlarge existing plant	- - - -
Parkston	1,200	Enlarge existing plant	- - - -

Table $I_{(5)}$ - (Continued)

Table $I_{(5)}$ - (Continued)

Name	Population served	Project requirements	Remarks
Bridgewater---	560	New plant needed	- - - -
Scotland------	900	Enlarge existing plant	- - - -

* Strength of industrial waste is measured in terms of equivalent numbers of people.

BIG SIOUX RIVER SUB-BASIN

Physical Description

Geography - The Sub-Basin has a maximum width of approximately 110 miles and a length of 250 miles, and occupies parts of the States of South Dakota, Minnesota, and Iowa. The area contains approximately 9,600 square miles, which represents 2 percent of the Missouri Basin. The natural boundaries are formed by the Minnesota River Watershed (Upper Mississippi Basin) to the north and east, the Floyd River Watershed to the south, and the Vermillion River Drainage Area on the west.

Topography - The Big Sioux River rises in Grant County in northeastern South Dakota and flows in a generally southern direction to join the Missouri River near Sioux City, Iowa. The lower one-third of the river forms the boundary between the States of Iowa and South Dakota. Its principal tributary, the Rock River, rises in southwestern Minnesota and flows in a southwesterly direction across northwestern Iowa to its confluence with the Big Sioux at a point approximately 10 miles north of Hawarden, Iowa.

The main stem of the Big Sioux River is approximately 400 miles long. The channel of the Big Sioux is rather well defined and stable but follows a meandering course through its valley. The main stem gradient slopes from 2 to 3 feet per mile and tributary streams slope considerably more.

The topographical conditions prevailing in the Sub-Basin make it admirably suited for livestock and grain production. The upper half of the Big Sioux Sub-Basin is typical prairie country with a few areas of gently sloping benchland. The lower half is characterized by its well defined valleys and alluvial bottom land. Soils for the most part are rich and deep.

Climate - Precipitation over the Sub-Basin averages 26.4 inches annually, and the mean annual temperatures average 45° F. Maximum and minimum recorded temperatures have been 114° F. and -41° respectively.

Economic Development - Agriculture in the Big Sioux Sub-Basin forms the backbone of the local economy, with approximately 98 percent of the area and 60 percent of the population engaged in agricultural pursuits. The present population of the Big Sioux Drainage Sub-Basin is estimated at 300,000 persons. Watertown and Sioux Falls, S. Dak., are the two largest cities within this Sub-Basin. The population of these cities is largely supported through industry and service operations based upon the agricultural economy. Meat packing is the largest single industry in the Sub-Basin, and both of the before-mentioned cities have large processing plants. Smaller abattoirs, locker plants and creameries are located in most of the other cities and towns.

The waters of the Big Sioux River are utilized primarily for livestock watering, recreation, game fishing, cooling water for industrial plants, and development of hydroelectric power. It is also used in one instance for municipal water supply and for minor irrigation.

Pollution Data

The summary of data available on sources and amounts of pollution originating within the Big Sioux River Sub-Basin, together with the kind of treatment installed and needed in the future, is shown in tables $A_{(6)}$ through $I_{(6)}$.

Table A(6) indicates that approximately 87 percent of the B.O.D. in terms of population equivalent is removed by treatment from the wastes contributed by both domestic and industrial sources tributary to municipal sanitary sewers. This is a high degree of removal and is the result of the efficient sewage treatment facilities located in industrial and population centers.

Table C(6) indicates that more than 75 percent of the municipalities of the Big Sioux River Sub-Basin have sewage treatment works and that almost 90 percent of population now connected to sanitary sewers is being served by sewage treatment plants. Yet, as will be noted in table $G_{(6)}$, only 11 percent of the domestic sewered population in the Big Sioux River Sub-Basin is provided with adequate treatment facilities to control properly stream pollution. The need for further sewage treatment works tends to illustrate the value placed on the streams of this Sub-Basin by State and local groups.

Table B(6) indicates that industrial wastes being discharged directly to the streams are largely of organic nature. However, the table does not include sand and gravel pits from which a considerable amount of silt may be discharged to watercourses.

Table D(6) indicates that, by and large, the industrial plants in the Sub-Basin are processing foodstuffs or kindred products. These consist of creameries, slaughterhouses, and rendering plants. Not listed in table D(6) is a large steam power generating plant located at Sioux City, Iowa, that uses waters of the Big Sioux River as a coolant.

Table E(6) indicates that 54 percent of the municipal sewage treatment plants have adequate capacity, and that 64 percent are operated satisfactorily. The rather low percentage of municipal waste treatment plants that have the necessary capacity to handle present loadings is probably due to the fact that most of them are between 20 and 30 years old, and that during this time the growth of population and industry has seriously overloaded these plants. This is particularly true in the smaller municipalities.

Table F(6) reveals that one new municipal sewage treatment plant and two new industrial waste treatment plants were constructed during the four years of 1946 through 1949 in the Sub-Basin.

Table G(6) indicates that 10 new municipal plants and 1 new industrial plant are needed, and that enlargements and additions to 9 other municipal plants and 1 industrial plant now in existence and the replacement of one existing municipal plant are necessary to provide adequate stream pollution control.

Table H(6) indicates that in about 35 percent of those instances where new plants and improvements to existing municipal treatment facilities have been recommended, some action has begun.

Table I(6) is a listing of the individual municipal or industrial waste treatment requirements of the Big Sioux River Sub-Basin. Where a new plant is indicated, the requirement may be based on the fact that no facility now exists or that the existing facility is so inadequate as to require an entirely new installation.

Where enlargement of an existing plant is indicated the requirement is based on information that existing facilities are overloaded or are otherwise not providing adequate treatment.

The project requirements listed are in some cases based on incomplete information and are subject to change after investigations have been completed by the State agency concerned.

The concentration of industry and population in this relatively small area has demonstrated that sewage and industrial waste treatment is necessary to maintain the streams of the Sub-Basin in a satisfactory condition, and that in spite of the general high degree of treatment prevailing, greater improvement in existing plants is still required to maintain the standards of stream cleanliness necessary to meet with the approval of the residents of the area. Since the Big Sioux River Sub-Basin contains area included in the States of South Dakota, Minnesota, and Iowa, a comprehensive coordinated program by the Water Pollution Control Agencies of these three States is necessary in order to fulfill properly the requirements of the Sub-Basin.

Table $A_{(6)}$ - Sources of pollution - Municipal

Municipalities*	Sources of pollution (In number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (In terms of equivalent number of people) **
Having data on pollution load discharged to watercourse	37	101,900***	51,100
Having population data available (Data on pollution load to watercourse incomplete or not available)	0	- - - -	- - - -
Total	37	101,900	51,100

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers, or other population centers; sanitary sewage wastes discharged by industry directly to watercourse.

** Includes industrial wastes discharged into municipal sewerage systems.

*** Data do not include industrial waste of 291,100 population equivalent discharging to municipal sewers.

Table B(6) - Sources of pollution - Industrial*

Industries	Sources of pollution (In number of plants)	Amount of pollution discharged to watercourse (In terms of equivalent number of people)
Producing organic wastes	5	3,500
Producing organic wastes	0	- - - -
Producing inorganic wastes	0	- - - -
Producing wastes of undetermined type	0	- - - -
Total	5	3,500

* Industries having separate outlets and discharging wastes directly to watercourse.

Table $C_{(6)}$ - Existing treatment facilities - Municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	6	6	4,100
Secondary	22	22	86,300
No treatment	9	- - - -	11,500

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

Table $D_{(6)}$ - Existing treatment facilities - Industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products---------	4	2	2	0
Chemical --------	1	1	0	0
Total	5	3	2	0

* Industries having separate outlets and discharging wastes directly to watercourse.

Table $E_{(6)}$ - Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to: Capacity: Satisfactory	Capacity: Unsatisfactory	Capacity: Undetermined	Operation: Satisfactory	Operation: Unsatisfactory	Operation: Undetermined
Municipal	28	15*	12	1	18	6	4
Industrial	3	2	1	0	3	0	0

* Includes one treatment plant where existing units have adequate capacity, but additional units are needed to provide a higher degree of treatment. These needs are reflected in table $G_{(6)}$.

Table $F_{(6)}$ - Progress in pollution abatement

Year	Municipal: Plants completed	Municipal: Design population	Industrial: Plants completed	Industrial: Amount of waste treated (In terms of equivalent number of people)
1946	0	- - - -	0	- - - -
1947	0	- - - -	1	3,000
1948	0	- - - -	1	870
1949	1	800	0	- - - -

Table $G_{(6)}$ - Requirements for municipal and industrial waste treatment plants

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	10*	19,800	1
Enlargement or additions to existing plant	9	67,200	1
Replace existing plant	1	700	0
No project required	14	10,400	2
Undetermined	3	3,800	1**

* Includes one existing facility which due to local conditions has been classified as needing a new plant rather than a replacement. ** One industrial plant does not at present have waste treatment facilities and need has not been determined.

Table $H_{(6)}$ - Status of treatment works project to abate pollution - July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	12	0
Abatement ordered*	0	0
Plans under preparation	3	0
Final plans approved	2	2
Construction awaiting financing	1	0
Under construction	1	0
Status undetermined	1	0

(Footnote continued)

(Footnote for Table $H_{(6)}$)

*** Formal orders to municipalities and industries for abatement of pollution have received little use as an administrative procedure in this Sub-Basin. Instead, State water pollution control agencies have preferred to use a cooperative approach in many cases to the extent of a forced agreement to secure abatement without actually exercising police power. Formal orders are reserved for use only in recalcitrant cases where the cooperative approach is not successful. Acceleration of abatement activities in this Sub-Basin may conceivably increase the use of formal orders as an administrative expedient.**

Table I(6) - Project list - Municipalities and industries requiring improvements for abatement of pollution - July 1, 1950

Name	Population served	Project requirements	Remarks
Iowa:			
Rock Rapids---	1,900	New plant needed	Planning initiated
Doon ---------	400	Enlarge existing plant	- - - -
George -------	700	Replace existing plant	- - - -
Sibley---------	1,400	Enlarge existing plant	Awaiting financing
Ashton--------	450	New plant needed	- - - -
Rock Valley---	1,000	Enlarge existing plant	- - - -
Hawarden-----	2,600	Needs undetermined	- - - -
Akron --------	1,000	Needs undetermined	- - - -
Minnesota:			
Lake Benton---	500	Enlarge existing plant	- - - -
Pipestone-----	4,750	Enlarge existing plant	- - - -
Jasper Industry-----	150*	Needs undetermined	- - - -
Luverne ------	2,000	New plant needed	Planning initiated
Rushmore-----	200	Needs undetermined	- - - -
Adrian--------	960	Enlarge existing plant	- - - -
South Dakota:			
Webster ------	2,500	Enlarge existing plant	Under construction
Watertown ----	10,245	Enlarge existing plant	- - - -

Table I(6) - (Continued)

Table $I_{(6)}$ - (Continued)

Name	Population served	Project requirements	Remarks
Abattoir-----	2,000*	New plant needed	Final plans approved
Clear Lake----	600	New plant needed	Final plans approved
Lake Preston--	900	New plant needed	- - - -
Brookings-----	5,310	New plant needed	- - - -
Madison ------	5,025	New plant needed	- - - -
Sioux Falls----	45,000	Enlarge existing plant	Planning initiated
Sioux Falls Rendering Co.	Not known	Enlarge existing plant	Final plans approved
Canton--------	2,000	New plant needed	- - - -
Hudson -------	450	New plant needed	- - - -
Beresford-----	1,200	New Plant needed	- - - -

* Strength of industrial waste measured in terms of equivalent numbers of people.

LOWER PLATTE RIVER SUB-BASIN

Physical Description

Geography - The Sub-Basin, with a maximum width of approximately 145 miles and a length of 350 miles, lies within the State of Nebraska. The area contains approximately 32, 500 square miles which represents 6 percent of the Missouri Basin. The natural boundaries are formed by the Niobrara River watershed to the north, the drainage area of the Main Stem Missouri River to the east, the Blue and Republican River watersheds on the south, and the North and South Platte River Sub-Basins to the west.

Topography - The main stem of the Platte River is formed by the junction of the North Platte and South Platte Rivers near North Platte, Nebr., and flows eastward across Nebraska for a distance of approximately 310 miles to join the Missouri River at Plattsmouth, Nebr., which is located 35 miles south of Omaha, Nebr. The principal tributaries in the Sub-Basin are the Loup and Elkhorn Rivers which drain areas lying north of the Platte River. These tributaries originate in the Great Sand Hills Country of west and central Nebraska which contributes much of the water carried by these streams. It has been said that the Sand Hills act as a great sponge and is the controlling factor which tends to stabilize both surface and ground water level throughout the Lower Platte River Valley.

The physical features of the Lower Platte Sub-Basin are essentially of two types. One, the so-called Sand Hills Country, consists of sandy soil whipped by the wind into dunes from 20 to 60 feet in height and sometimes higher and which are interspersed at frequent intervals by small lakes. The second type of topography in evidence is that of the plains region with broad flat river valleys rising to gently sloping uplands. Soils having the latter type of topography range from light sandy in the western extremity of the Sub-Basin to those of heavy fines, better known as loess in its eastern extremity.

Climate - The climate varies from semiarid in the west to that of a subhumid condition at its eastern extremity. Precipitation varies between 18 inches in the western section to about 30 inches in its eastern part; the average temperature is about 47 ° F.

Economic Development - Agriculture and related activities form the basis of economy for the region as it does for most of the other Sub-Basins of the Missouri River Basin. The raising and marketing of livestock is the largest single source of revenue to the inhabitants. Cereal, sugar beets, potatoes, and legumes are the other agricultural crops of importance. Industry within the Lower Platte River drainage area is principally that needed to support the agricultural economy, and consists of meat packing plants, creameries, beet sugar refineries, and other types of food processing plants.

Pollution Data

The summary of data on source and amount of pollution in the Lower Platte River Sub-Basin, together with the kind of treatment installed and needed, is shown in table $A_{(7)}$ through $I_{(7)}$.

Table $A_{(7)}$ indicates that 26 percent or more of the B. O. D. contributed by combined domestic and industrial wastes in terms of population equivalent units is removed from waste prior to its discharge into the watercourses. In addition to the domestic population served by sewer systems, 165, 300 population equivalents originating within industrial establishments are discharged to municipal sewers (footnote table $A_{(7)}$).

Table $B_{(7)}$ indicates that industrial plants discharging wastes to the watercourses are very limited in number, with most of the waste originating from one plant which operates seasonally during the months of October, November, and December

Table $C_{(7)}$ indicates that 48 percent of the municipalities having sewage collection systems employ sewage treatment and 56 percent of the population served by sewers is connected to treatment works.

Table $D_{(7)}$ shows that three of the four industrial establishments contributing wastes directly to watercourses are associated with the processing of foodstuffs.

Table $E_{(7)}$ indicates that the design capacity of municipal sewage treatment facilities is adequate in 57 percent of the installations, and operation of these facilities is satisfactory in 61 percent.

Table F(7) reveals that 3 new municipal sewage treatment works were constructed during the four years 1946 through 1949. No new industrial waste treatment works were constructed during this period.

Table G(7) shows a need for 47 new municipal waste treatment plants and for improvements to 15 existing facilities. These new plants and improvements would provide better service for approximately 86 percent of the sewered population.

According to Table H(7), 6 of the 62 municipalities whose requirements are shown in Table G(7) have begun action to provide the necessary pollution abatement facilities. An analysis of the statistics on pollution in the Lower Platte River Sub-Basin would indicate that there is need for an effective abatement program.

Table I(7) is a listing of the individual municipal and industrial waste treatment needs of the Sub-Basin.

The Lower Platte River and its tributaries are little used as sources of domestic water supply, there being only one city, Ord, Nebr., which utilizes a surface source. The principal use of the waters of the Lower Platte River is that of providing for the numerous existing irrigation projects and the ones planned for the future. There has been limited use of these streams for fish and wildlife propagation. Other uses have been those of providing water for livestock and hydroelectric power, and for carrying away sanitary and industrial wastes.

Table $A_{(7)}$ - Sources of pollution - Municipal

Municipalities*	Sources of pollution (In number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (In terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	80	245,100***	300,400
Having population data available (Data on pollution load to watercourse incomplete or not available)	1	100	Not applicable
Total	81	245,200	- - - -

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers, or other population centers; sanitary sewage wastes discharged by industry directly to watercourse.

** Includes industrial wastes discharged into municipal sewerage systems.

*** Data do not include industrial waste of 165,300 population equivalent discharging to municipal sewers.

Table $B_{(7)}$ - Sources of pollution - Industrial*

Industries	Sources of pollution (In number of plants)	Amount of pollution discharged to watercourse (In terms of equivalent number of people)
Producing organic wastes	4**	67,000***
Producing organic wastes	0	- - - -
Producing inorganic wastes	1	- - - -
Producing wastes of undetermined type	0	- - - -
Total	4****	67,000

* Industries having separate outlets and discharging wastes directly to watercourse.

** Includes 1 plant also producing inorganic wastes.

*** One plant seasonal - 65,700 population equivalent.

**** Total adjusted to correct for duplication noted in footnote marked thus**.

Table $C_{(7)}$ - Existing treatment facilities - Municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	18	18	15,900
Secondary	21	21	122,100
No treatment	42	- - - -	107,200

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

Table $D_{(7)}$ - Existing treatment facilities - Industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products ---------	3	1	2	0
Nonmanufacturing	1**	1	0	0
Total	4	2	2	0

* Industries having separate outlets and discharging wastes directly to watercourse.

** Roundhouse.

Table $E_{(7)}$ - Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satis-factory	Unsatis-factory	Unde-termined	Satis-factory	Unsatis-factory	Unde-termined
Municipal	39	22*	16	1	24	11	4
Industrial	2	1	1	0	1	1	0

* Includes 4 treatment plants where existing units have adequate capacity, but additional units are needed to provide a higher degree of treatment. These needs are reflected in table $G_{(7)}$.

Table $F_{(7)}$ - Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (In terms of equivalent number of people)
1946	0	- - - -	0	- - - -
1947	1	1,200	0	- - - -
1948	1	6,500	0	- - - -
1949	1	250	0	- - - -

Table $G_{(7)}$ - Requirements for municipal and industrial waste treatment plants

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	47*	105,300	2
Enlargement or additions to existing plant	12	94,900	0
Replace existing plant	3	10,900	1
No project required	18	33,700	1
Undetermined	1	400	0

* Includes 5 existing facilities which due to local conditions have been classified as needing new plants rather than replacements.

Table $H_{(7)}$ - Status of treatment works project to abate pollution - July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	56	2
Abatement ordered*	0	0
Plans under preparation	1	0
Final plans approved	3	0
Construction awaiting financing	0	0
Under construction	1	0
Status undetermined	1	1

(Footnote continued)

(Footnote for Table $H_{(7)}$)

* Formal orders to municipalities and industries for abatement of pollution have received little use as an administrative procedure in this Sub-Basin. Instead, State water pollution control agencies have preferred to use a cooperative approach working closely with polluters in an attempt to secure abatement without exercising police power. Acceleration of abatement activities in this Sub-Basin may conceivably increase the use of formal orders as an administrative expedient.

Table $I_{(7)}$ - Project list - Municipalities and industries requiring improvements for abatement of pollution - July 1, 1950

Name	Population served	Project requirements	Remarks
Nebraska:			
North Platte---	15,000	New plant needed	- - - -
Gothenburg----	2,800	New plant needed	Final plans approved
Cozad --------	3,600	New plant needed	Final plans approved
Lexington-----	3,000	Replace existing plant	Final plans approved
Elm Creek----	400	Needs undetermined	- - - -
Kearney------	10,480	New plant needed	- - - -
Gibbon--------	500	New plant needed	- - - -
Grand Island Sugar Beet Refinery-----	65,700*	New plant needed	Seasonal
Central City---	1,890	Enlarge existing plant	Under construction
Silver Creek --	300	New plant needed	- - - -
Burwell ------	800	New plant needed	- - - -
Ord ----------	1,100	New plant needed	- - - -
Thedford------	250	New plant needed	- - - -
Loup City-----	820	New plant needed	- - - -
Gallaway------	900	Enlarge existing plant	- - - -
Broken Bow---	3,000	Enlarge existing plant	- - - -

Table $I_{(7)}$ - (Continued)

Table $I_{(7)}$ - (Continued)

Name	Population served	Project requirements	Remarks
Ravenna ------	1,600	New plant needed	- - - -
Roundhouse wastes ------	120*	Replace existing plant	Oily wastes
Milk plant (Dannebrog)--	290*	New plant needed	- - - -
St. Paul ------	1,710	New plant needed	- - - -
Spalding ------	800	New plant needed	- - - -
Cedar Rapids--	600	New plant needed	- - - -
Fullerton -----	1,530	New plant needed	- - - -
Albion--------	1,685	New plant needed	- - - -
St. Edward----	890	New plant needed	- - - -
Genoa --------	1,000	New plant needed	- - - -
Columbus-----	7,070	Replace existing plant	- - - -
Schuyler------	2,500	New plant needed	- - - -
Newman Grove	850	New plant needed	- - - -
Lindsay-------	100	Enlarge existing plant	- - - -
Stuart --------	400	Enlarge existing plant	- - - -
Atkinson------	1,200	New plant needed	- - - -
O'Neill -------	2,500	New plant needed	- - - -
Neligh--------	1,750	New plant needed	- - - -

Table $I_{(7)}$ - (Continued)

Table $I_{(7)}$ - (Continued)

Name	Population served	Project requirements	Remarks
Tilden	850	Replace existing plant	- - - -
Meadow Grove	370	Enlarge existing plant	- - - -
Battle Creek	702	Enlarge existing plant	- - - -
Norfolk	11,700	New plant needed	- - - -
Pierce	1,010	New plant needed	- - - -
Madison	1,800	New plant needed	- - - -
Humphrey	800	New plant needed	- - - -
Stanton	930	New plant needed	- - - -
Pilger	550	New plant needed	- - - -
Wisner	1,260	New plant needed	- - - -
Beemer	585	New plant needed	- - - -
West Point	2,030	New plant needed	- - - -
Scribner	910	New plant needed	- - - -
Dodge	650	New plant needed	- - - -
Snyder	325	Enlarge existing plant	- - - -
Hooper	700	New plant needed	- - - -
Laurel	600	New plant needed	- - - -
Winside	400	New plant needed	- - - -

Table $I_{(7)}$ - (Continued)

Table $I_{(7)}$ - (Continued)

Name	Population served	Project requirements	Remarks
Wayne	4,000	New plant needed	- - - -
Wakefield	1,150	New plant needed	- - - -
Pender	1,350	New plant needed	Planning initiated
Lyons	1,000	New plant needed	- - - -
Oakland	1,330	New plant needed	- - - -
Leigh	575	Enlarge existing plant	- - - -
Clarkson	1,000	Enlarge existing plant	- - - -
Howells	600	Enlarge existing plant	- - - -
Fremont	13,600	New plant needed	- - - -
Lincoln	85,000	Enlarge existing plant	- - - -
Ashland	1,000	New plant needed	- - - -
Weston	100	New plant needed	- - - -
Wahoo	3,300	New plant needed	- - - -
Louisville	300	New plant needed	- - - -

* Strength of industrial waste measured in terms of equivalent numbers of people.

NORTH PLATTE RIVER SUB-BASIN

Physical Description

Geography - The Sub-Basin, with a maximum width of 220 miles and a length of 430 miles, occupies parts of the States of Wyoming, Nebraska, and Colorado. The area encompasses approximately 34,400 square miles, which represents 7 percent of the Missouri River Basin. The natural boundaries are formed by the Continental Divide to the west, the Niobrara Watershed and the Yellowstone River Sub-Basin to the north, the Lower Platte River Sub-Basin to the east, and the South Platte Sub-Basin to the south.

Topography - The source of the North Platte River lies nearly 13,000 feet above sea level in the snowcapped Medicine Bow and Sierra Madre Ranges of the Rocky Mountains of northern Colorado. From there it flows northward into Wyoming and across the high plateaus to a point near Casper in east central Wyoming, and then southeasterly into the State of Nebraska and finally joins the South Platte River near North Platte, Nebr.

The North Platte has a length of 665 miles from its source to mouth. It is a comparatively swift flowing stream with an average gradient of ten and one-half feet per mile above Casper, Wyo., and 6 feet per mile from Casper to the mouth. The Sweetwater River and the Laramie River are the two principal tributaries of the North Platte. The Sweetwater River rises in west central Wyoming and flows eastwardly to its confluence with the North Platte. The Laramie River rises in northern Colorado and flows in a northerly direction to its confluence with the North Platte.

Climate - The climatic conditions of the North Platte Sub-Basin are those of a semiarid high plains region with the annual mean temperature in the mountain section being 35° F., while that in the lower plains region is approximately 44° F. Annual precipitation varies over the Sub-Basin from 10 to 15 inches.

Economic Development - The early history of the North Platte region indicates that the first economy of the locale was based on ranching and raising of livestock, with a comparatively small number of people inhabitating the area. Later large quantities of oil were located and a large oil producing and refining industry was established. Within the last 50 years an extensive amount of irrigation has been practiced, the principal crops being cereal and sugar beets. One of its really great natural resources, however, is water. Flows of the North Platte and tributaries have been and are being impounded in numerous places along its course for the purposes of developing vast amounts of power and for regulating the stream for irrigation purposes. The water has added also to the recreational values of the mountainous sections of the North Platte Sub-Basin.

The principal cities which have grown up in the North Platte Sub-Basin are Casper, Laramie, and Torrington, Wyo.; and Scottsbluff, Nebr.

Pollution Data

The summation of statistical data on the kind and amount of pollution originating in the North Platte River Sub-Basin, together with the existing treatment works and future needs, are shown in tables $A_{(8)}$ through $I_{(8)}$.

Table $A_{(8)}$ indicates that about 10 percent of the B.O.D. in terms of population equivalents is removed by treatment facilities before the waste is discharged to the stream. A relatively small number of industrial establishments contribute wastes to municipal sewer systems, and as yet these wastes have not been evaluated in terms of population equivalents. These industries, however, are located principally in one city of approximately 35,000 inhabitants which at the present time does not have a treatment works.

Table $B_{(8)}$ indicates that a relatively large number of industrial establishments are located in the North Platte Sub-Basin, consisting mostly of sugar refineries and petroleum refineries. The former produces a seasonal waste but one which exerts a tremendous biochemical oxygen demand upon the stream and which may coincide with the critical flow period of the stream. The petroleum refineries contribute both organic and inorganic materials to the stream in the nature of oil, phenol, and chemical wastes.

Table $C_{(8)}$ indicates that only 30 percent of the municipalities having sanitary sewers are provided with treatment works, and that these treatment works serve 23 percent of the sewered population. Table $E_{(8)}$

indicates that design capacity of municipal plants is satisfactory in 67 percent of the installations. Table $D_{(8)}$ shows that 35 percent of the industrial plants are provided with treatment facilities and table $E_{(8)}$ indicates that 40 percent of the existing facilities are satisfactorily designed and all are being satisfactorily operated.

Table $F_{(8)}$ indicates that 3 new municipal sewage treatment plants were constructed in the Sub-Basin during the period 1946 through 1949. No industrial waste treatment works were constructed during this period.

Table $G_{(8)}$ shows that only 2 percent of the sewered population is provided with adequate treatment facilities, that there is need for 23 new sewage treatment plants, and improvements at 1 existing plant. Table $H_{(8)}$ notes that there has been little or no action by the municipalities toward bringing about the required improvements outlined in table $G_{(8)}$. Only one municipality has initiated plans for the recommended improvement.

Table $I_{(8)}$ reveals the waste treatment requirements of the individual municipality or industry. The requirements as listed may be changed somewhat when present investigations under way in the North Platte Sub-Basin have been completed.

The rather sparse urban population in the North Platte Sub-Basin, and the fact that most of the municipalities are located on streams of considerable discharge, is reflected in that sewage treatment has not been demanded by local groups. In recent years the establishment of industries in the Sub-Basin has caused some concern to water users in the lower half of the main stem of the North Platte River. Investigations under way at the present time will undoubtedly determine the extent to which this section of the stream has been damaged by industrial and domestic wastes.

Table A (8) - Sources of pollution - Municipal

Municipalities*	Sources of pollution (In number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (In terms of equivalent number of people) **
Having data on pollution load discharged to watercourse	28	75, 600***	115, 100
Having population data available (Data on pollution load to watercourse incomplete or not available)	2	2, 200	Not applicable
Total	30	77, 800	- - - -

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers, or other population centers; sanitary sewage wastes discharged by industry directly to watercourse. ** Includes industrial wastes discharged into municipal sewerage systems. *** Data do not include industrial waste of 44, 900 population equivalents discharging to municipal sewers.

Table B (8) - Sources of pollution - Industrial*

Industries	Sources of pollution (In number of plants)	Amount of pollution discharged to watercourse (In terms of equivalent number of people)
Producing organic wastes	3**	917, 000
Producing organic wastes	11***	Undetermined
Producing inorganic wastes	6	- - - -
Producing wastes of undetermined type	0	- - - -
Total	14****	- - - -

* Industries having separate outlets and discharging wastes directly to watercourse. ** Seasonal operation. *** Includes 6 plants also producing inorganic wastes. **** Total adjusted to correct for duplication noted in footnote marked thus***.

Table C (8) - Existing treatment facilities - Municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	6	6	17, 900
Secondary	3	3	600
No treatment	21	- - - -	59, 300

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

Table D (8) - Existing treatment facilities - Industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products ---------	8	0	8	0
Petroleum products ---------	6	5	1	0
Total -------	14	5	9	0

* Industries having separate outlets and discharging wastes directly to watercourse.

Table E$_{(8)}$ - Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	9	6	3	0	6	1	2
Industrial	5	2	3	0	5	0	0

Table F$_{(8)}$ - Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (In terms of equivalent number of people)
1946	0	- - - -	0	- - - -
1947	1	160	0	- - - -
1948	0	- - - -	0	- - - -
1949	2	3,000	0	- - - -

Table G (8) - Requirements for municipal and industrial waste treatment plants

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	23*	75, 300	6
Enlargement or additions to existing plant	1	800	4
Replace existing plant	0	- - - -	0
No project required	6	1, 700	1
Undetermined	0	- - - -	3

* Includes 2 existing facilities which due to local conditions have been classified as needing a new plant rather than a replacement.

Table H (8) - Status of treatment works project to abate pollution - July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	23	9
Abatement ordered*	0	0
Plans under preparation	1	0
Final plans approved	0	0
Construction awaiting financing	0	0
Under construction	0	1
Status undetermined	0	0

* Formal orders to municipalities and industries for abatement of pollution have received little use as an administrative procedure in this Sub-basin. Instead, State water pollution control agencies

(Footnote continued)

Footnote for Table $H_{(8)}$

have preferred to use a cooperative approach, working closely with polluters in an attempt to secure abatement without exercising police power. Formal orders are used generally only in recalcitrant cases where cooperative approach has not been successful. Acceleration of abatement activities in this Sub-basin may conceivably increase the use of formal orders as an administrative expedient.

Table I(8) - Project list - Municipalities and industries requiring improvements for abatement of pollution - July 1, 1950

Name	Population served	Project requirements	Remarks
Nebraska:			
Lyman --------	300	New plant needed	- - - -
Sugar Refinery--	Not known	Needs undetermined	- - - -
Morrill --------	600	New plant needed	- - - -
Mitchell -------	1, 800	New plant needed	- - - -
Great Western Sugar Company--	197, 000*	New plant needed	- - - -
Coop. Oil Refinery--------	Not known	Needs undetermined	- - - -
Scottsbluff ------	9, 000	New plant needed	- - - -
Great Western Sugar Company--	705, 000*	New plant needed	- - - -
Co-Op. Cannery-	46, 580*	New plant needed	- - - -
Gering ---------	2, 000	New plant needed	- - - -
Great Western Sugar Company--	470, 000*	New plant needed	- - - -
Minatare--------	800	New plant needed	- - - -
Melbeta --------	75	New plant needed	- - - -
Bayard ---------	1, 700	New plant needed	- - - -
Gr. Western Sugar Co. -------	197, 000*	New plant needed	- - - -
Bridgeport ------	1, 000	New plant needed	- - - -
Coldwell Packing Co.-------------	252*	Needs undetermined	- - - -
Broadwater -----	150	New plant needed	- - - -
Oshkosh --------	700	New plant needed	- - - -

(Table I(8) - continued)

Table I$_{(8)}$ - (continued)

Name	Population served	Project requirements	Remarks
Wyoming:			
Rawlins --------	6,000	New plant needed	- - - -
Sinclair - - - - -	850	Enlarge existing plant	- - - -
Medicine Bow - -	450	New plant needed	- - - -
Casper ---------	25,000	New plant needed	- - - -
Standard Oil Refinery --------	Not known	Enlarge existing plant	- - - -
Socony-Vacuum Oil Co. ---------	Not known	Enlarge existing plant	- - - -
Texas Oil Co. Refinery --------	Not known	Enlarge existing plant	- - - -
Evansville ------	350	New plant needed	- - - -
Glenrock -------	1,250	New plant needed	- - - -
Continental Oil Ref. --------	Not known	Enlarge existing plant	Under construction
Douglas --------	2,600	New plant needed	- - - -
Guernsey -------	700	New plant needed	- - - -
Laramie -------	14,000	New plant needed	- - - -
Wheatland ------	2,500	New plant needed	Planning initiated
Chugwater ------	250	New plant needed	- - - -
Lingle ----------	550	New plant needed	- - - -
Torrington ------	3,500	New plant needed	- - - -
Holly Sugar Co. Ref. --------	250,000*	New plant needed	- - - -

* Strength of industrial waste measured in terms of equivalent numbers of people.

SOUTH PLATTE RIVER SUB-BASIN

Physical Description

Geography - The South Platte River Sub-Basin, with a maximum width of 170 miles and a length of 320 miles, occupies parts of the States of Wyoming, Nebraska,and Colorado. The area contains approximately 25, 500 square miles which represents 5 percent of the Missouri River Basin. The natural boundaries are formed by the Continental Divide to the west, the North Platte Sub-Basin to the north, the Kansas River Sub-Basin to the east, and the Arkansas River Watershed to the south.

Topography - The South Platte River rises in the high Rocky Mountains of Colorado along the precipitous eastern slope. The river flows for a distance of approximately 450 miles in a northeasterly direction to join the North Platte River near North Platte, Nebr., to form the main Platte River. The entire Sub-Basin lies at an elevation above 3, 000 feet and about 75 percent of it lies at an elevation above 6, 000 feet.

The gradient of the South Platte and its tributaries is relatively steep, and the stream velocities are swift.

Climate - The climatic conditions in the Sub-Basin are those of a semiarid region, with rainfall that averages approximately 30 inches in the high mountain section to only 10 1/2 inches in the lower plains area. The streams in the mountains are perennial in nature while those of the plains are very erratic in their flow. The variances of elevations within the Sub-Basin result in temperatures that vary between relatively mild areas and those which have very severe climate. The mean annual temperature in the high mountainous region is 34 °F., while that in the lower plains region is approximately 50 °F.

Economic Development - Much of the early economy of this Sub-Basin was based on its mineral wealth; large quantities of gold and silver were taken from the mountainous section. With the decline in mine production many of the inhabitants turned to farming and ranching. As the climate was not suitable for agriculture without irrigation, some of the earliest irrigation projects in the nation were established in the South Platte River Valley. With the addition of water, the soils along the

South Platte produced heavy crops of foodstuffs. Thus the City of Denver, located in a highly fertile region on one side and extensive mining wealth on the other, became a rapidly growing metropolitan center.

There is located at Denver a wide variety of industry. There is also a considerable amount of industry established along the main stem of the South Platte from Denver to its mouth. These plants are primarily canneries and beet sugar refineries.

In the mountainous sections above Denver many parks have been established which have in recent years become a mecca for the tourists of America.

The South Platte Sub-Basin has become cognizant in recent years of a shortage of water for irrigation and other purposes. The City of Denver has also recognized the fact that its water supply was limited. Water is now being diverted into the South Platte Sub-Basin from the western slope of the Continental Divide for domestic and irrigation purposes, and additional diversions are in progress. It is apparent however that the available water supply will govern the ultimate expansion of either agriculture or industry in this region.

Pollution Data

The summation of data on sources and amounts of pollution in the South Platte River Sub-Basin, together with the kind of present treatment and future needs for facilities, is shown in tables $A_{(9)}$ through $I_{(9)}$.

Table $A_{(9)}$ indicates that present municipal sewage treatment facilities remove 31 percent of the B.O.D. contributed by industrial and domestic wastes tributary to sewer systems. At least 307,400 population equivalent units of industrial wastes not shown in the table (footnote table $A_{(9)}$ are tributary to municipal sewer systems.

Table $B_{(9)}$ indicates that there are a relatively large number of industrial plants located in the South Platte River Sub-Basin; 13 of the plants producing organic wastes are sugar refineries which contribute enormous amounts of waste to the stream during the seasonal operation which occurs in the months of October, November and December.

In addition to these plants there are a considerable number of packing plants and canneries also contributing large amounts of organic wastes. Inorganic wastes are derived principally from the residues of mining and smelting operations.

Table C(9) indicates that about 73 percent of the municipalities having sewers are serviced with treatment works, and that these treatment works serve 92 percent of the population residing in the municipalities.

In Table G(9) it is indicated that only 5 percent of the population connected to sewers are provided with adequate treatment facilities. New plants and improvements to sewage works are needed to effect better treatment for the remaining 95 percent of the population.

Table D(9) indicates that there are 61 industries which produce organic wastes, such as meat packing plants, canneries and sugar refineries; 21 percent of these plants provide some type of treatment.

Table E(9) shows that the capacity of municipal sewage treatment plants is adequate in 31 percent of the installations, and that about 50 percent of the plants receive satisfactory operation.

Table F(9) reveals that one new municipal waste treatment plant was constructed in the South Platte River Sub-Basin during the period 1946 through 1949.

Table H(9) indicates that only 7 of the 46 municipalities where new plants or improvements have been indicated in Table G(9) have begun action to improve or provide treatment for their municipal wastes.

Table I(9) points out the sewage treatment needs of the individual municipalities and in a general way, the waste treatment needs of the industrial establishments. The requirements as listed may be somewhat changed when the investigation report now being written by the State of Colorado, the Bureau of Reclamation, and the Public Health Service on pollution in the South Platte River has been completed.

Although these statistics indicate that there is 31 percent removal of the B. O. D. in terms of population equivalent units affected through the municipal sewage treatment plants, they also indicate that only

about 5 percent of the sewered population are provided with treatment facilities adequate to meet the requirements of pollution control. The extreme value of water within the South Platte River Sub-Basin makes it imperative that a high degree of treatment be provided if the maximum use of existing water is to be realized. The extensive development of industry in the Sub-Basin, for which adequate treatment has not yet been provided, adds greatly to an already critical situation.

Table A$_{(9)}$ - Sources of pollution - Municipal

Municipalities*	Sources of pollution (In number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (In terms of equivalent number of people) **
Having data on pollution load discharged to watercourse	51	629, 300 ***	647, 300
Having population data available (Data on pollution load to watercourse incomplete or not available)	2 ****	200	Not applicable
Total	53	629, 500	- - - -

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers, or other population centers; sanitary sewage wastes discharged by industry directly to watercourse. ** Includes industrial wastes discharged into municipal sewerage systems. *** Data do not include industrial waste of 307, 400 population equivalent discharging to municipal sewers. **** Includes one sanitary district for which population served is unknown.

Table B$_{(9)}$ - Sources of pollution - Industrial*

Industries	Sources of pollution (In number of plants)	Amount of pollution discharged to watercourse (In terms of equivalent number of people)
Producing organic wastes	45**	4, 182, 100
Producing organic wastes	1	Undetermined
Producing inorganic wastes	18	Not applicable
Producing wastes of undetermined type	0	- - - -
Total	61 ***	- - - -

* Industries having separate outlets and discharging wastes directly to watercourse. ** Includes 3 plants also producing inorganic wastes. *** Total adjusted to correct for duplication noted in footnote marked thus **.

Table C(9) - Existing treatment facilities - Municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	20	21	498, 300
Secondary	18	18	83, 300
No treatment	15	- - - -	47, 900

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

Table D(9) - Existing treatment facilities - Industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products	43	5	23	15
Chemical	1	0	0	1
Mining	5	1	4	0
Petroleum	3	3	0	0
Primary metals	9	4	5	0
Total	61	13	32	16

* Industries having separate outlets and discharging wastes directly to watercourse.

Table E$_{(9)}$ - Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satis-factory	Unsatis-factory	Unde-termined	Satis-factory	Unsatis-factory	Unde-termined
Municipal	39	12*	25	2	20	12	7
Industrial	13	0	2	11	0	1	12

* Includes 6 treatment plants where existing units have adequate capacity, but additional units are needed to provide a higher degree of treatment. These needs are reflected in Table G$_{(9)}$.

Table F$_{(9)}$ - Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (In terms of equivalent number of people)
1946	0	- - - -	0	- - - -
1947	0	- - - -	0	- - - -
1948	1	5,225	0	- - - -
1949	0	- - - -	0	- - - -

Table G(9) - Requirements for municipal and industrial waste treatment plants

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	16*	52, 200	34**
Enlargement or additions to existing plant	28	540, 700	0
Replace existing plant	2	4, 300	0
No project required	6	32, 000	0
Undetermined	2	300	27

* Includes one existing facility which due to local conditions has been classified as needing a new plant rather than a replacement. ** Includes two existing facilities which due to local conditions has been classified as needing new plants rather than replacements.

Table H(9) - Status of treatment works project to abate pollution - July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	37	30
Abatement ordered *	0	0
Plans under preparation	2	4
Final plans approved	0	0
Construction awaiting financing	0	0
Under construction	5	0
Status undetermined	2	0

* Formal orders to municipalities and industries for abatement of pollution have received little use as an administrative procedure in this Sub-basin. Instead, States water pollution control agencies

(Footnote continued)

Footnote for Table H

(9)

have preferred to use a cooperative approach, working closely with polluters in an attempt to secure abatement without exercising police power. Formal abatement orders have in general been used only in recalcitrant cases where the cooperative approach has been unsuccessful. Acceleration of abatement activities in this Sub-basin may conceivably increase the use of formal orders as an administrative expedient.

Table $I_{(9)}$ - Project list - Municipalities and industries requiring improvements for abatement of pollution - July 1, 1950

Name	Population served	Project requirements	Remarks
Colorado:			
Alma	469	New plant needed	- - - -
Mine tailings	Not known	Needs undetermined	- - - -
Dredge operations	Not known	Needs undetermined	- - - -
Castlerock	580	Enlarge existing plant	- - - -
Louviers	160	Needs undetermined	- - - -
Chemical	Not known	Needs undetermined	- - - -
Littleton	2, 660	Replace existing plant	Under construction
Dairy	260	Needs undetermined	- - - -
Federal Correctional Inst.	500	Enlarge existing plant	- - - -
Ft. Logan	3, 000	Enlarge existing plant	- - - -
Loretto Heights College	400	Enlarge existing plant	- - - -
Denver	410, 000	Enlarge existing plant	Under construction
Dairy	250*	New plant needed	- - - -
Dairy	25*	New plant needed	- - - -
Dairy	75*	Needs undetermined	- - - -
Rendering co.	750*	New plant needed	- - - -
Packing plant	4, 800*	New plant needed	- - - -
Packing co.	600*	New plant needed	- - - -
Packing Co.	1, 860*	New plant needed	- - - -

(Table $I_{(9)}$ - continued)

Table I$_{(9)}$ - (continued)

Name	Population served	Project requirements	Remarks
Colorado:			
Denver:			
Packing co.	740*	New plant needed	- - - -
Packing co.	3, 310*	New plant needed	- - - -
Dairy	33*	Needs undetermined	- - - -
Aurora	10, 500	Enlarge existing plant	- - - -
East Denver Municipal Treatment Plant	25, 000	Enlarge existing plant	- - - -
Oil refining co.	Not known	Needs undetermined	- - - -
Petroleum co.	Not known	Needs undetermined	- - - -
Petroleum co.	Not known	Needs undetermined	- - - -
Dairy	350*	New plant needed	- - - -
Denver Municipal Airport	300	Enlarge existing plant	- - - -
Silver Plume	140	Needs undetermined	- - - -
Mining co.	Not known	Needs undetermined	- - - -
Georgetown	120	New plant needed	- - - -
Idaho Springs	2, 500	New plant needed	- - - -
Ore processing mill	Not known	Needs undetermined	- - - -
Ore processing	Not known	Needs undetermined	- - - -
Ore processing	Not known	Needs undetermined	- - - -
Ore processing	Not known	Needs undetermined	- - - -

(Table I$_{(9)}$ - continued)

Table $I_{(9)}$ - (continued)

Name	Population served	Project requirements	Remarks
Colorado:			
Idaho Springs			
Ore processing	Not known	Needs undetermined	- - - -
Ore processing	Not known	Needs undetermined	- - - -
Mining	Not known	Needs undetermined	- - - -
Ore processing	Not known	Needs undetermined	- - - -
Golden	3, 400	New plant needed	Planning initiated
Brewery	12, 200*	New plant needed	Planning initiated
Brewery	300*	New plant needed	Planning initiated
Tannery	320*	New plant needed	Planning initiated
Wheatridge Sanitary Dist.	Not known	New plant needed	Under construction
Arvada	2, 000	Enlarge existing plant	Under construction
Packing co.	1, 800*	New plant needed	Planning initiated
Westminster	1, 700	Enlarge existing plant	- - - -
Packing co.	Not known	Needs undetermined	- - - -
Brighton	4, 500	Enlarge existing plant	- - - -
Cannery	7, 500*	Needs undetermined	- - - -
Sugar refinery	180, 000*	Needs undetermined	- - - -
Ft. Lupton	2, 200	Enlarge existing plant	- - - -
Sugar refinery	Not known*	Needs undetermined	Not currently operating

(Table $I_{(9)}$ - continued)

Table I$_{(9)}$ - (continued)

Name	Population served	Project requirements	Remarks
Colorado:			
Platteville	700	New plant needed	- - - -
Longmont	8, 000	Enlarge existing plant	- - - -
Packing house	Not known	Needs undetermined	- - - -
Cannery	18, 000*	New plant needed	- - - -
Sugar refinery	700, 000*	New plant needed	- - - -
Ore processing	Not known	Needs undetermined	- - - -
Lafayette	1, 250	New plant needed	Under construction
Mining	Not known	Needs undetermined	- - - -
Boulder	21, 400	Enlarge existing plant	- - - -
Estes Park	850	Enlarge existing plant	- - - -
Bureau of Reclamation	300	Enlarge existing plant	- - - -
Loveland (No. 1 plant)	6, 000	Enlarge existing plant	- - - -
Loveland (No. 2 plant)	2, 000	Enlarge existing plant	- - - -
Cannery	1, 560*	New plant needed	- - - -
Cannery	2, 500*	New plant needed	- - - -
Cannery	9, 600*	New plant needed	- - - -
Sugar refinery	640, 000	New plant needed	- - - -
Milliken	500	New plant needed	- - - -
Berthoud	1, 000	Enlarge existing plant	- - - -

(Table I (9) - continued)

Table $I_{(9)}$ - (continued)

Name	Population served	Project requirements	Remarks
Colorado:			
Johnson ------	1, 200	New plant needed	- - - -
Sugar refinery-	Not known	New plant needed	- - - -
Milk processing	455*	Needs undetermined	- - - -
La Salle ------	1, 000	Enlarge existing plant	- - - -
Evans --------	250	Enlarge existing plant	- - - -
Wellington ----	465	Enlarge existing plant	- - - -
Ft. Collins			
Cannery -----	Not known	New plant needed	- - - -
Milk processing	3, 360*	New plant needed	- - - -
Sugar refinery-	710, 000*	New plant needed	- - - -
Windsor -------	2, 000	Enlarge existing plant	
Sugar refinery-	210, 000*	New plant needed	- - - -
Eaton ---------	1, 300	Enlarge existing plant	- - - -
Sugar refinery-	140, 000*	New plant needed	- - - -
Greeley--------	21, 000	Enlarge existing plant	- - - -
Rendering works	410*	New plant needed	- - - -
Warehouse-----	2, 300*	New plant needed	- - - -
Sugar refinery-	180, 000*	New plant needed	- - - -
Slaughterhouse-	120*	New plant needed	- - - -
Deer Trail-----	387	New plant needed	- - - -

(Table $I_{(9)}$ - continued)

Table I$_{(9)}$ - (continued)

Name	Population served	Project requirements	Remarks
Colorado:			
Ft. Morgan ----	6,000	Enlarge existing plant	- - - -
Sugar refinery -	450,000*	New plant needed	- - - -
Brush ---------	3,000	New plant needed	- - - -
Sugar refinery -	250,000*	New plant needed	- - - -
Merino --------	300	New plant needed	- - - -
Sterling -------	8,000	Enlarge existing plant	- - - -
Rendering works	Not known	New plant needed	- - - -
Sugar refinery -	360,000*	New plant needed	- - - -
Ovid ---------	800	New plant needed	- - - -
Sugar refinery -	290,000*	New plant needed	- - - -
Julesberg ------	1,800	New plant needed	- - - -
Potato warehouse ---------	Not known	Needs undetermined	- - - -
Nebraska:			
Chappel -------	1,000	Enlarge existing plant	- - - -
Ogalalla -------	1,600	Replace existing plant	- - - -
Wyoming:			
Cheyenne ------	35,000	New plant needed	Planning initiated
Pine Bluffs ----	800	New plant needed	- - - -

* Strength of industrial waste is measured in terms of equivalent numbers of people.

KANSAS RIVER SUB-BASIN

Physical Description

Geography - The Kansas River Sub-Basin has a maximum width of 200 miles and a length of 495 miles, and occupies parts of the States of Nebraska, Colorado, and Kansas. The area encloses approximately 60,600 square miles, which represents 12 percent of the Missouri River Basin. The natural boundaries are formed by the Platte River drainage area to the north, the drainage area of the Main Stem Missouri River to the east, and Arkansas River watershed to the south, and the South Platte Sub-Basin to the west.

Topography - The main stem of the Kansas River is formed by the junction of the Republican and Smoky Hill Rivers and is 169 miles in length from the point of this junction to its confluence with the Missouri River at Kansas City, Kan. Other large streams of the Sub-Basin are the Blue, Saline, and Solomon Rivers. The mean annual flow of the Kansas River is 5,870 c.f.s., however, mean monthly flows may drop as low as 570 c.f.s. about once each 10 years.

Other topographical features of the Kansas Sub-Basin are those of the plains region, there being no mountains or unusual topography within the Sub-Basin. The river valleys for the most part are broad and rise to gently sloping uplands on either side.

Climate - The climate of the Kansas Sub-Basin varies from semiarid in its western reaches to semihumid in the eastern extremity, with rainfall varying from 15 to 32 inches per annum. The mean temperature of the Sub-Basin is approximately 50° F., with recorded variations between a -38° F. and 116°F.

Economic Development - The natural resources of the area are principally those of its water and its soils, however, considerable wealth in the form of oil, salt, coal, and other mineral deposits are also present. Rather extensive oil and gas fields are to be found in west central Kansas. The soils within the Sub-Basin vary from relatively poor to extremely high fertility, with most of the better land located along the rivers and in the eastern one-third of the Sub-Basin.

The economy of the Kansas Sub-Basin is based primarily on agriculture; however, in recent years a great expansion of industry has occurred, principally along the lower reaches of the Kansas River. These new industries are connected with the processing of foodstuffs, the producing of chemicals and fertilizer, and the manufacturing of heavy equipment and machinery.

Pollution Data

The summary of data on source and amount of pollution in the Kansas River Sub-Basin, together with the kind of treatment presently installed and needed in the future, is shown in tables $A_{(10)}$ through $I_{(10)}$.

Table $A_{(10)}$ indicates that, with the inclusion of industrial wastes discharging to municipal sewers, treatment facilities remove 37 percent of the B. O. D. in terms of population equivalent units. The population equivalent of these industrial wastes, as noted in the footnote of table $A_{(10)}$ amounts to 202, 900 units.

Table $B_{(10)}$ indicates that there are a considerable number of industrial plants discharging organic wastes directly to watercourses of the Kansas River Sub-Basin. In addition to the sources of pollution noted, there are unknown amounts of waste from the several oil producing fields which are largely inorganic in nature and whose volume is difficult to ascertain.

Table $C_{(10)}$ shows that 72 percent of the municipalities having sewers also provide sewage treatment. These treatment plants service approximately 55 percent of the connected population. The latter percentage would be much higher if the larger centers of population within the Sub-Basin were provided with sewage treatment facilities.

Table $D_{(10)}$ denotes that industrial installations processing food and kindred materials far outnumber other types of manufacturing establishments. The number of treatment facilities provided for industrial wastes is very small.

Table $E_{(10)}$ indicates that 64 percent of the municipal sewage treatment plants now operating have adequate capacity and that 77 percent of the plants are being properly operated. Existing industrial waste treatment plants apparently do not have adequate capacity and are in need of more satisfactory operation.

Table F (10) reveals that 20 new municipal sewage treatment plants have been constructed in the Kansas Sub-Basin during the four years beginning in 1946 through 1949. No industrial waste plants were constructed during the same period.

Table G (10) evidences the need for 48 new municipal waste treatment plants, with additions to or replacements of existing facilities at 32 other municipalities. Only twenty-one percent of the population connected to sewerage systems for which treatment needs have been determined is now adequately provided with sewage treatment facilities.

Table H (10) reveals rather remarkable progress in the Kansas River Sub-Basin toward providing the municipal requirements listed in Table G (10). Action has begun in 66 percent of the instances where new municipal treatment plants or improvements to existing facilities have been requisite to proper stream pollution control.

Table I (10) indicates the waste treatment needs of the municipalities and industrial plants of the Kansas River Sub-Basin.

The extensive use of water for many purposes in the Sub-Basin will be greatly implemented by the progressive abatement program which has been inaugurated by the Water Pollution Control Agency for the State of Kansas. The industrial potential of the area drained by the Kansas River and its tributaries is very great, particularly in the lower end of the Sub-Basin, and it is imperative, therefore, that the waters be protected against undue pollution. In the headwaters of the Kansas Sub-Basin irrigation and stock watering are the principal uses, while in the lower end of the Sub-Basin water for domestic and industrial purposes becomes highly important. In their natural state the waters of the Sub-Basin are not in general conducive to the propagation of fishlife nor recreational uses due to silt load; however, there has been and will be an increased amount of construction activity for the purpose of improving both recreational uses of water and for increasing its value as a means of propagating fish and other wildlife dependent on water.

The mineral characteristics of the waters in the Kansas River are for the most part satisfactory for all indicated uses; however, some of the tributaries, particularly the Saline and Smoky Hill Rivers, are such that they are of little value for domestic water sources. The mineral constituents of these waters arise from possibly two sources: the first is from the natural salt beds underlying a large segment of the area, and the second from the pollution of the waterways by brine waste from the oil fields. It is fortunate, however, that the waters bearing high mineral contents are so highly diluted prior to their extensive use for domestic and industrial purposes that they remain usable.

Table A(10) - Sources of pollution - Municipal

Municipalities*	Sources of pollution (In number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (In terms of equivalent number of people) **
Having data on pollution load discharged to watercourse	152	507, 200***	452, 600
Having population data available (Data on pollution load to watercourse incomplete or not available)	5****	1, 200	Not applicable
Total	157	508, 400	- - - -

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers, or other population centers; sanitary sewage wastes discharged by industry directly to watercourse. ** Includes industrial wastes discharged into municipal sewerage systems. *** Data do not include industrial waste of 202, 900 population equivalents discharging to municipal sewers. **** Three municipalities have collection systems with unknown "population served."

Table B$_{(10)}$ - Sources of pollution - Industrial*

Industries	Sources of pollution (In number of plants)	Amount of pollution discharged to watercourse (In terms of equivalent number of people)
Producing organic wastes	23**	721,900
Producing organic wastes	1	Undetermined
Producing inorganic wastes	5***	Not applicable
Producing wastes of undetermined type	1	- - - -
Total	26****	- - - -

* Industries having separate outlets and discharging wastes directly to watercourse. ** Includes 4 plants also producing inorganic wastes. *** 1 ordnance plant - intermittent operation. **** Total adjusted to correct for duplication as noted in footnote marked **.

Table C(10) - Existing treatment facilities - Municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	20	20	101,600
Secondary	92**	92	177,500
No treatment	45***	- - - -	229,400

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers. ** Includes two plants for which "population served" is unknown. *** Includes one system for which "population served" is unknown.

Table D(10) - Existing treatment facilities - Industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products ----------	18	2	15	1
Paper and allied products ----------	1	0	1	0
Chemical and allied products ----	4	1	3	0
Products of petroleum and coal -	2	1	1	0
Rubber products ---	1	1	0	0
Total -------	26	5	20	1

* Industries having separate outlets and discharging wastes directly to watercourse.

Table $E_{(10)}$ - Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	112	72*	34	6	86	14	12
Industrial	5	2	1	2	3	0	2

* Includes one treatment plant where existing units have adequate capacity, but additional units are needed to provide a higher degree of treatment. These needs are reflected in Table $G_{(10)}$.

Table $F_{(10)}$ - Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (In terms of equivalent number of people)
1946	1	330	0	- - - -
1947	5	14, 020	0	- - - -
1948	7	7, 700	0	- - - -
1949	7	21, 350	0	- - - -

Table $G_{(10)}$ - Requirements for municipal and industrial waste treatment plants

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	48*	231,600	11
Enlargement or additions to existing plant	21	125,000	1
Replace existing plant	11	22,100	0
No project required	71	107,900	3**
Undetermined	6	21,800	11

* Includes three existing facilities which due to local conditions have been classified as needing new plants rather than replacements.

** Includes one industry not now having treatment.

Table $H_{(10)}$ - Status of treatment works project to abate pollution - July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	27	11
Abatement ordered	46	1
Plans under preparation	3	0
Final plans approved	1	0
Construction awaiting financing	0	0
Under construction	3	0
Status undetermined	0	0

Table I$_{(10)}$ - Project list - Municipalities and industries requiring improvements for abatement of pollution - July 1, 1950

Name	Population served	Project requirements	Remarks
Colorado:			
Wray	2,400	Needs undetermined	- - - -
Haxtun	700	New plant needed	Under construction
Holyoke	900	Enlarge existing plant	Planning initiated
Burlington	1,900	Enlarge existing plant	- - - -
Cheyenne Wells	250	Needs undetermined	- - - -
Kansas:			
Goodland	2,800	Enlarge existing plant	- - - -
Atwood	1,400	Replace existing plant	- - - -
Colby	3,190	Enlarge existing plant	- - - -
Norton State Sanatorium	500	Needs undetermined	- - - -
Scandia	475	New plant needed	- - - -
Mankato	1,130	New plant needed	- - - -
Concordia	5,750	New plant needed	- - - -
Belleville	2,000	Replace existing plant	- - - -
Clyde	770	Enlarge existing plant	- - - -
Clifton	520	Enlarge existing plant	- - - -
Clay Center	4,000	New plant needed	- - - -
Wakefield	500	New plant needed	- - - -

(Table I$_{(10)}$ - continued)

Table $I_{(10)}$ - (continued)

Name	Population served	Project requirements	Remarks
Kansas:			
Junction City --	10, 700	New plant needed	- - - -
Sharon Springs -	710	Replace existing plant	- - - -
Ellis ---------	1, 840	Enlarge existing plant	- - - -
Russell -------	5, 000	Enlarge existing plant	- - - -
Wilson -------	700	Enlarge existing plant	- - - -
Ellsworth, Slaughterhouse -	230*	New plant needed	- - - -
Marquette -----	665	New plant needed	- - - -
Osborne ------	1, 800	Replace existing plant	- - - -
Phillipsburg ---	2, 080	Replace existing plant	- - - -
Co-Op Oil Refinery ------	2, 500*	Needs undetermined	- - - -
Downs --------	1, 250	Replace existing plant	- - - -
Beloit --------	3, 500	New plant needed	- - - -
Glasco -------	600	New plant needed	- - - -
Delphos -------	400	New plant needed	- - - -
Minneapolis ---	1, 650	New plant needed	- - - -
Solomon ------	750	New plant needed	- - - -
Abilene -------	5, 000	Enlarge existing plant	- - - -
Enterprise ----	650	New plant needed	- - - -
Chapman -----	830	New plant needed	- - - -

(Table $I_{(10)}$ - continued)

Table $I_{(10)}$ - (continued)

Name	Population served	Project requirements	Remarks
Kansas:			
Ft. Riley -----	13,000	Needs undetermined	- - - -
Ogden --------	450	New plant needed	- - - -
Manhattan ----	21,100	New plant needed	- - - -
Patterson Harwood Lab. -	2,670*	New plant needed	- - - -
Dearborn Packing Plant------	240*	New plant needed	- - - -
Marysville ----	4,000	New plant needed	- - - -
Hanover ------	600	New plant needed	- - - -
Waterville ----	650	New plant needed	- - - -
Blue Rapids ---	1,250	New plant needed	- - - -
Axtell --------	485	Enlarge existing plant	- - - -
Frankfort -----	1,000	New plant needed	- - - -
Wamego ------	1,520	New plant needed	- - - -
St. Mary's ----	1,175	Replace existing plant	- - - -
St. Mary's College -------	225	Replace existing plant	- - - -
Topeka -------	70,800	Enlarge existing plant	- - - -
Boys' Industrial School ---	200	New plant needed	Under construction
Horton -------	2,400	Replace existing plant	- - - -
Valley Falls---	1,000	New plant needed	- - - -

(Table $I_{(10)}$ - continued)

Table I$_{(10)}$ - (continued)

Name	Population served	Project requirements	Remarks
Kansas:			
Mitchell Sausage Factory	190*	New plant needed	- - - -
Lawrence	26,900	New plant needed	- - - -
Lawrence Paper Co.	4,400*	New plant needed	- - - -
Haskell Institute	- - - -	Enlarge existing plant	- - - -
Eudora	750	New plant needed	Planning initiated
Tonganoxie			
Franklin Ice Cream Co.	4,000*	Enlarge existing plant	- - - -
De Soto	320	New plant needed	- - - -
Bonner Springs	1,850	New plant needed	- - - -
R. B. Rice Sausage Co.	290*	New plant needed	- - - -
Kuhn Cannery	13,400*	New plant needed	- - - -
Olathe	4,300	Enlarge existing plant	- - - -
Kansas City	103,000	New plant needed	- - - -
Sinclair Petroleum	7,200*	New plant needed	- - - -
Proctor & Gamble	23,600*	New plant needed	- - - -
10 Packing Plants	645,000*	Needs undetermined (10)	- - - -
Colgate-Palmolive Peet Co.	20,000*	New plant needed	- - - -

(Table I$_{(10)}$ - continued)

Table I$_{(10)}$ - (continued)

Name	Population served	Project requirements	Remarks
Nebraska:			
Benkelman ----	1,600	Replace existing plant	- - - -
Wauneta ------	800	New plant needed	- - - -
Madrid -------	Not known	New plant needed	Under construction
Palisade -----	430	Enlarge existing plant	- - - -
Cilbertson ----	600	New plant needed	- - - -
Mc Cook ------	7,500	Replace existing plant	Planning initiated
Indianola -----	800	Enlarge existing plant	- - - -
Curtis --------	900	Enlarge existing plant	- - - -
Arapahoe -----	1,000	New plant needed	- - - -
Beaver City ---	1,000	Enlarge existing plant	- - - -
Orleans ------	815	New plant needed	- - - -
Alma --------	1,700	New plant needed	- - - -
Holdredge-----	4,600	Needs undetermined	- - - -
Franklin -----	1,600	New plant needed	- - - -
Red Cloud ----	1,500	New plant needed	- - - -
Superior ------	2,800	New plant needed	- - - -
Stromsborg ---	1,000	New plant needed	- - - -
Ulysses-------	300	New plant needed	- - - -
Staplehurst ---	200	Enlarge existing plant	- - - -

(Table I$_{(10)}$ - continued)

Table $I_{(10)}$ - (continued)

Name	Population served	Project requirements	Remarks
Nebraska:			
Seward --------	2, 800	New plant needed	- - - -
Milford --------	1, 000	New plant needed	- - - -
Hastings -------	20, 000	Enlarge existing plant	Final plans approved
Sutton ---------	1, 000	Needs undetermined	- - - -
Crete ---------	3, 500	Enlarge existing plant	- - - -
Wilber --------	850	New plant needed	- - - -
Beatrice -------	8, 000	New plant needed	- - - -
Ayr Slaughterhouse-	152*	New plant needed	- - - -
Nelson ---------	750	New plant needed	- - - -
Hebron --------	2, 000	New plant needed	- - - -
Fairbury -------	7, 200	New plant needed	- - - -

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* Strength of industrial waste is measured in terms of equivalent numbers of people.

LOWER MISSOURI RIVER SUB-BASIN

Physical Description

Geography - The Lower Missouri Sub-Basin, with a maximum width of 135 miles and a length of 550 miles, occupies parts of the States of South Dakota, Minnesota, Nebraska, Iowa, Kansas, and Missouri. The area encompasses approximately 37,300 square miles, which represents 7 percent of the Missouri River Basin. The natural boundaries are formed by the James River and Big Sioux watersheds to the north, the drainage area of the Mississippi River and Grand-Chariton River Sub-Basin to the east, the Osage River Sub-Basin to the south, and the Lower Platte and Kansas River Sub-Basins to the west.

Topography - The Lower Missouri River Sub-Basin includes that area drained by the Missouri River and its tributaries below the mouth of the James River with the following exceptions: the drainage basins of the Big Sioux, Platte, Kansas, Grand, Chariton, Osage and Gasconade Rivers. Approximately 835 miles of the main stem of the Missouri River flows through this section. Minor tributaries within the Sub-Basin include the Vermillion River in South Dakota; the Floyd, Little Sioux and Boyer Rivers in Iowa; the Big and Little Nemaha Rivers in Nebraska and Kansas; the Nishnabotna and Platte Rivers which drain portions of Iowa and Missouri; and the Lamine River lying south of the main stem of the Missouri River in the State of Missouri.

Above the mouth of the James River the Missouri is confined by a rather narrow valley, while below the valley broadens and ranges from one and one-half to 15 miles in width from there to the mouth. It is within this lower reach that the Missouri has earned its fame for being a tempestuous stream.

The surface features of the Lower Missouri Sub-Basin may be described as a broad plains region with rolling to hilly uplands interspersed with narrow valleys formed by comparatively sharp erosion. The deep wind-blown fines known as loess soil are primarily responsible for the characteristic erosion which occurs. The soils, being very stable, are eroded by water in such a fashion as to form steep banks. The main stem of the Missouri River is somewhat more confined in the lower 300 miles of its course because of the geological formations through which it flows. The rock formation is not as easily eroded as the glaciated area through which the river traverses above this point.

Climate - The climatological characteristics of the Sub-Basin are those of a subhumid climate. Rainfall averages from 22 to 46 inches per year and the mean annual temperature is approximately 53 ° F.

Hydrology - Stream flow data indicate that the mean annual flow during the past 20 years in the main stem of the Missouri River at Yankton, S. Dak., is approximately 24,000 c.f.s., and the mean annual flow at Hermann, Mo., near the mouth, amounts to 68,600 c.f.s. The fifty year record at the same points indicates the annual flows may be nearly 32,000 c.f.s. and 90,000 c.f.s. respectively.

The gradient of the stream through this 835 miles is comparatively steep, averaging .85 of a foot per mile. The velocity of the flow considerably exceeds that of most streams comparable in size, consequently the Missouri is extremely turbulent and carries huge quantities of silt throughout its entire lower reach.

Economic Development - This section of the Missouri River Basin was the first to be settled and has steadily increased in population. At present approximately 40 percent of the 8,200,000 people residing in the Missouri Drainage Basin live in the Lower Missouri Sub-Basin. With the river as a highway upon which large volumes of commerce could be carried, it was natural that large metropolitan centers should have developed along its banks. The cities of Kansas City and St. Joseph, Mo.; Omaha, Nebr., and Sioux City, Iowa, became the marketing and trading centers for the entire Middle West. The high fertility of the soil produced large quantities of foodstuffs, much of which was shipped from the Sub-Basin. The same cities also became important rail centers, either terminal points or points from which the railroads extended farther west. With the necessary raw products so close at hand, particularly those associated with agriculture, large installations for food handling and processing have been constructed in the four cities mentioned. Not only has there been a tendency to develop large industrial centers in the Lower Missouri Sub-Basin, but there has been a multitude of villages and small cities developed as local trade centers.

The development of the mineral resources of the region is limited to those used for construction materials and to the bituminous coal deposits found in southern Iowa and north central Missouri. There are no other mineral resources of note within the Sub-Basin.

In recent years the river has become extremely important as a source of domestic water supply and as a means of removal and ultimate disposal of both domestic and industrial wastes. As the populations increase these uses will become even more important.

Pollution Data

The summation of data available on the source and amount of pollution, together with the kind and amount of treatment installed and needed, is shown in tables A(11) through I(11).

An analysis of the data contained in table A(11) indicates that 17 percent of the B. O. D. has been removed by treatment of wastes from domestic and industrial sources which are discharged to municipal sewers. Approximately 249, 300 population equivalent units originate from industry connected to municipal sewer systems (footnote table A(11)). Table B(11) shows that 26 industries, 22 of which are connected in some manner with the processing of foodstuffs, contribute 1, 883, 600 population equivalent units directly to streams of the Sub-Basin. This table does not include those industries such as steam power generating plants which use great quantities of water for cooling purposes. There are several plants of the latter type in the Lower Missouri River Sub-Basin. Inorganic pollution in the form of silt, which is being contributed from sand and gravel sluicing pits, also is not shown in table B(11).

It will be noted (table C(11)) that 67 percent of municipalities and institutions within the Lower Missouri River Sub-Basin are served by treatment works. However, only 26 percent of the total sewered population is served by these plants.

The large centers of population such as Sioux City, Iowa, a large part of Omaha, Nebr., and St. Joseph and Kansas City, Mo., are not at the present time served by sewage treatment works. Table D(11) indicates a considerable variety of industrial establishments which are discharging waste directly to watercourses. The preponderance of these industries are connected in some manner with the processing of food. The meat packing industry, the largest contributors of waste, is located in the principal cities.

Table E(11) indicates that 65 percent of the municipal sewage treatment plants have adequately designed units and that nearly 80 percent of them are operated satisfactorily. Industrial establishments do not have nearly as good a record.

Table F(11) reveals that 6 new municipal sewage treatment works and 1 new industrial waste treatment plant were constructed during the period beginning in 1946 through 1949.

Table G(11) indicates that 85 new sewage treatment plants and improvements or additions to 67 other existing municipal treatment facilities are needed. The new plants and improvements to existing facilities are necessary to provide adequate service for at least 42 percent of population now connected to sewers. It is evident from table G (11) that only approximately 18 percent of the population connected to sewerage systems or 118,011 persons, for which pollutional data are available are provided with entirely adequate treatment facilities.

Table H(11) indicates that action toward improving existing sewerage treatment facilities and for constructing new sewage treatment works has begun in about 25 percent of the municipalities where definite need has been indicated.

Table I(11) lists the project needs for municipalities and industries of the Lower Missouri Sub-Basin. Where a new plant is indicated the requirement may be based on the fact that no facility now exists, or that the existing facility is so inadequate as to require an entirely new installation. Where enlargement of an existing plant is indicated, the requirement is based on information that existing facilities are overloaded or are otherwise not providing adequate treatment.

The project requirements listed are in some cases based on incomplete information and are subject to change after investigations have been completed by the State agency concerned. A survey of the Lower Main Stem of the Missouri River is now in progress. The data obtained during this survey will be useful in reconciling any inconsistencies in project needs shown in Table I for municipalities discharging directly into the river and will aid in determining the project requirements now listed as "undetermined" on this reach of the stream. Investigations of stream conditions are also necessary on other streams of the Sub-Basin to determine the final project needs.

The water resources of the Lower Missouri River Sub-Basin are used largely for domestic and sanitary purposes, for navigation, for industrial processing and cooling water, for commercial fishing, stock watering, and recreational purposes. Water for domestic purposes is largely derived from the main stem of the Missouri River. Although tremendous quantities of polluting material from both industrial and domestic sources enter the main stem, they have not yet acutely affected domestic water supplies, that limit, however, is rapidly being approached. Water generally has been plentiful for the dilution of wastes in this section of the Missouri River Basin during the past, and only in the minor tributaries has it been necessary to provide sewage treatment to escape local nuisance conditions.

There are many desirable industrial locations within this Sub-Basin, and it is logical to expect that an industrial expansion will be noticeable throughout the area in the very near future. The favorable climate of the region precludes the possibility that there will be much irrigation. The water uses by both municipalities and industry are great, with industry using approximately four times the average domestic consumption. Waters thus used are generally returned to the stream in practically undiminished quantity but do contain the wastes from industry and the domestic population. Stream regulation for navigation will, during the navigation season, provide flows consistent with industrial and municipal needs.

There are a few natural lakes lying in this Sub-Basin, namely the Okoboji lake system in northern Iowa and several oxbow lakes along the main stem of the Missouri River which do afford recreational facilities such as bathing, boating, and swimming, and to a minor extent game fishing.

Ground waters are relatively easy to locate and are of good quality throughout the Sub-Basin. Most of the smaller municipalities therefore secure their water for domestic purposes from ground water sources. The larger cities excepting Sioux City, Iowa, must obtain the quantity of water they need from the main stem of the Missouri

River. Sioux City, Iowa, is extremely fortunate in having an exceedingly large amount of ground water available at a shallow depth from which both domestic and industrial water is taken.

Table A (11) - Sources of pollution - Municipal

Municipalities*	Sources of pollution (In number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (In terms of equivalent number of people) **
Having data on pollution load discharged to watercourse	258	1,257,100***	1,253,200
Having population data available (Data on pollution load to watercourse incomplete or not available)	4	7,600	Not applicable
Total	262	1,264,700	- - - -

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers, or other population centers; sanitary sewage wastes discharged by industry directly to watercourse. ** Includes industrial wastes discharged into municipal sewerage systems. *** Data do not include industrial waste of 249,300 population equivalents discharging to municipal sewers.

Table B (11) - Sources of pollution - Industrial *

Industries	Sources of pollution (In number of plants)	Amount of pollution discharged to watercourse (In terms of equivalent number of people)
Producing organic wastes	15	1,883,600
Producing organic wastes	8 **	Undetermined
Producing inorganic wastes	4	Not applicable
Producing wastes of undetermined type	0	- - - -
Total	26 ***	1,883,600

* Industries having separate outlets and discharging wastes directly to watercourse. ** One plant also produces inorganic wastes. *** Total adjusted to correct for duplication as noted in footnote marked **

Table C (11) - Existing treatment facilities - Municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	37	40	25, 800
Secondary	140	153	302, 500
No treatment	85	- - - -	936, 400

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

Table D (11) - Existing treatment facilities - Industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Foods and kindred products ----------	22	5	17	0
Products of petroleum and coal-	1	1	0	0
Mine drainage -----	1 area	0	1	0
Chemical and allied products ----	1	1	0	0
Primary metals ---	1	0	1	0
Total ------	26	7	19	0

* Industries having separate outlets and discharging wastes directly to watercourse.

Table E$_{(11)}$ - Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	193	126*	64	3	154	31	8
Industrial	7	2	1	4	3	0	4

* Includes 29 treatment plants where existing units have adequate capacity, but additional units are needed to provide a higher degree of treatment. These needs are reflected in Table G$_{(11)}$

Table F$_{(11)}$ - Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (In terms of equivalent number of people)
1946	0	- - - -	0	- - - -
1947	0	- - - -	1	- - - -
1948	1	150	0	- - - -
1949	5	10,600	0	- - - -

Table G (11) - Requirements for municipal and industrial waste treatment plants

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	85	333, 200	11
Enlargement or additions to existing plant	49	175, 300	0
Replace existing plant	18	14, 300	0
No project required	97	118, 000	3*
Undetermined	29	623, 900	12

* Includes one industry not now having treatment.

Table H (11) - Status of treatment works project to abate pollution - July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	98	9
Abatement ordered *	1	0
Plans under preparation	13	0
Final plans approved	13	0
Construction awaiting financing	0	0
Under construction	10	0
Status undetermined	17	2

* Formal orders to municipalities and industries for abatement of pollution have received little use as an administrative procedure in this Sub-basin. Instead, State water pollution control agencies

(Footnote continued)

Footnote for Table H (11)

have preferred to use a cooperative approach, in many cases to the extent of a forced agreement to secure abatement without actually exercising police power. Formal orders are reserved for use only in recalcitrant cases where the cooperative approach is not successful. Acceleration of abatement activities in this Sub-basin may conceivably increase the use of formal orders as an administrative expedient.

Table $I_{(11)}$ - Project list - Municipalities and industries requiring improvements for abatement of pollution - July 1, 1950

Name	Population served	Project requirements	Remarks
Iowa:			
Sioux City	70,000	Needs undetermined	- - - -
Industries	850,000*	Needs undetermined	- - - -
Sanborn	900	Replace existing plant	- - - -
Hospers	400	Enlarge existing plant	- - - -
LeMars	4,500	New plant needed	- - - -
Rendering plant	Not known	New plant needed	- - - -
Boyden	487	Enlarge existing plant	- - - -
Creamery	800*	New plant needed	- - - -
Hull	900	Enlarge existing plant	Final plans approved
Creamery	800*	New plant needed	- - - -
Sioux Center	1,600	Enlarge existing plant	Final plans approved
Maurice	210	Enlarge existing plant	- - - -
Orange City	1,300	Enlarge existing plant	- - - -
Merrill	400	New plant needed	- - - -
Hinton	300	New plant needed	- - - -
Onawa	2,700	New plant needed	Under construction
Milford	700	Replace existing plant	- - - -
Ocheyedan	400	Enlarge existing plant	- - - -
Everly	400	Enlarge existing plant	- - - -

Table $I_{(11)}$ - (Continued)

Table $I_{(11)}$ - (Continued)

Name	Population served	Project requirements	Remarks
Spencer----------	6,000	Enlarge exist-plant--------	- - - -
Sioux Rapids-----	800	New plant needed ------	- - - -
Linn Grove------	200	New plant needed ------	- - - -
Sutherland -------	750	Enlarge Existing plant-----	- - - -
Primghar --------	900	Replace existing plant-----	- - - -
Paullina ---------	1,000	New plant needed ------	- - - -
Washta ----------	350	Enlarge existing plant-----	- - - -
Correctionville ---	800	Enlarge existing plant-----	- - - -
Anton-------------	600	Replace exist-plant --------	- - - -
Smithland --------	400	Needs undetermined	- - - -
Marcus ----------	800	Replace existing plant-----	- - - -
Kingsley ---------	900	Replace existing plant-----	- - - -
Moville ----------	870	Replace existing plant-----	- - - -
Aurelia ----------	760	Replace existing plant -----	- - - -
Alta -------------	970	Exlarge existing plant-----	Final plans approved
Galva Rendering plant	Not known	New plant needed ------	- - - -
Odebolt ----------	1,250	Enlarge existing plant ----	Planning initiated
Arthur-----------	150	Replace existing plant-----	- - - -
Battle Creek -----	550	New plant needed ------	- - - -

Table $I_{(11)}$ - (Continued)

Table $I_{(11)}$ - (Continued)

Name	Population served	Project requirements	Remarks
Danbury	500	New plant needed	- - - -
Mapleton	1,400	New plant needed	- - - -
Ricketts	100	Enlarge existing plant	- - - -
Early	450	Enlarge existing plant	- - - -
Wall Lake	640	Replace existing plant	Final plans approved
Denison	3,700	New plant needed	- - - -
Westside	300	Enlarge existing plant	- - - -
Vail	350	New plant needed	- - - -
Dows City	400	New plant needed	- - - -
Dunlap	1,200	New plant needed	- - - -
Woodbine	1,000	New plant needed	- - - -
Logan	1,400	New plant needed	- - - -
Missouri Valley	3,200	New plant needed	- - - -
Carter Lake	600	Needs undetermined	- - - -
Council Bluffs	43,500	Needs undetermined	- - - -
Neola	700	Enlarge existing plant	- - - -
Rendering plant	Not known	New plant needed	- - - -
Iowa School for the Deaf (Council Bluffs)	400	New plant needed	- - - -

Table $I_{(11)}$ - (Continued)

Table I(11) - (Continued)

Name	Population served	Project requirements	Remarks
Glenwood--------	2,500	New plant needed ------	Final plans approved
Rendering plant	Not known	New plant needed ------	- - - -
Packing plant--	10,000*	New plant needed ------	- - - -
State School (Glenwood) ------	2,000	New plant needed ------	Final plans approved
Manilla ---------	700	Replace existing plant-----	- - - -
Harlan----------	2,100	Replace existing plant-----	Under construction
Avoca ----------	1,200	New plant needed ------	- - - -
Hancock---------	220	Enlarge existing plant-----	- - - -
Oakland---------	1,000	New plant needed ------	- - - -
Rendering plant	Not known	New plant needed ------	- - - -
Carson ---------	400	New plant needed ------	- - - -
Shelby ----------	350	Replace existing plant ----	- - - -
Malvern --------	1,250	New plant needed ------	Final plans approved
Exira-----------	750	Enlarge existing plant-----	- - - -
Atlantic Rendering plant	Not known	New plant needed ------	- - - -
Anita -----------	750	New plant needed ------	- - - -
Griswold--------	800	New plant needed ------	- - - -
Elliott ----------	450	New plant needed ------	- - - -
Red Oak --------	5,600	New plant needed ------	- - - -

Table I(11) - (Continued)

Table $I_{(11)}$ - (Continued)

Name	Population served	Project requirements	Remarks
Essex ---------	650	New plant needed ------	- - - -
Shenandoah-----	6,500	New plant needed ------	- - - -
Farragut-------	350	New plant needed ------	- - - -
Hamburg-------	1,000	New plant needed ------	- - - -
Taber----------	900	Replace existing plant-----	- - - -
Stanton---------	450	Replace existing plant-----	- - - -
Villisca--------	700	New plant needed ------	Planning initiated
Clarinda -------	4,500	New plant needed ------	Planning initiated
State Hospital (Clarinda)------	2,050	New plant needed ------	Planning initiated
Corning Rendering plant	Not known	New plant needed ------	- - - -
Lenox ---------	400	Replace existing plant -----	- - - -
Bedford--------	1,800	Enlarge existing plant-----	- - - -
Kansas:			
Seneca --------	1,700	Replace existing plant-----	- - - -
Sabetha --------	1,700	Enlarge existing plant-----	Planning initiated
Robinson-------	300	Enlarge existing plant-----	- - - -
Wathena -------	700	Enlarge existing plant ----	- - - -
Atchison -------	11,000	New plant needed ------	- - - -
Ft. Leavenworth----------	Not known	Needs undetermined	- - - -

Table $I_{(11)}$ - (Continued)

Table $I_{(11)}$ - (Continued)

Name	Population served	Project requirements	Remarks
Leavenworth ---	15,000	New plant needed ------	Planning initiated
Wadsworth -----	3,500	New plant needed ------	- - - -
Kansas State Penitentiary (Lansing) ------	3,000	New plant needed ------	Planning initiated
Missouri:			
Rockport-------	700	New plant needed ------	- - - -
Tarkio---------	500	New plant needed ------	- - - -
Fairfax --------	200	New plant needed ------	- - - -
Mound City-----	760	New plant needed ------	- - - -
Burlington Junction -------	280	New plant needed ------	- - - -
Maitland -------	460	New plant needed ------	- - - -
St. Joseph -----	73,000	Needs undetermined	- - - -
Two industries	300,000*	Needs undetermined	- - - -
Weston --------	200	New plant needed ------	- - - -
Maryville ------	4,200	New plant needed ------	- - - -
Plattsburg -----	840	Enlarge 2 existing plants	- - - -
Smithville -----	410	Enlarge existing plant ----	- - - -
North Kansas City -----------	2,300	Needs undetermined	- - - -
President Gardens Housing Development ---	1,500	Enlarge existing plant -----	Under construction

Table $I_{(11)}$ - (Continued)

Table $I_{(11)}$ - (Continued)

Name	Population served	Project requirements	Remarks
Sheffield Steel Co.------------	Not known	Needs undetermined	- - - -
Kansas City ----	360,000	Needs undetermined	- - - -
Jackson Co. Sewer District #1, West Outfall ----------	13,000	Needs undetermined	- - - -
Sugar Creek----	2,000	Needs undetermined	- - - -
Standard Oil Refinery ---------	Not known	Needs undetermined	- - - -
Inter-City Sewer District #1, East Outfall---------	3,000	Needs undetermined	- - - -
Jackson Co. Girls Home-----	75	New plant needed------	Under construction
Lee's Summit, S.W. Plant-----	565	Enlarge existing plant----	- - - -
Lee's Summit, N.W. Plant-----	340	Enlarge existing plant----	- - - -
Unity Farms----	Not known	Enlarge existing plant----	- - - -
Lake City Ordnance Works (Industrial wastes)	Not known	Needs undetermined	Stand-by basis
Lee's Summit --	565	Enlarge existing plant-----	- - - -
McCune Home --	100	New plant needed ------	- - - -
Independence (East Plant)----	2,000	New plant needed ------	- - - -
Liberty --------	2,800	Needs undetermined	- - - -
Excelsior Springs	3,670	Enlarge existing plant-----	- - - -
Lexington ------	2,300	Needs undetermined	- - - -

Table $I_{(11)}$ - (Continued)

Table $I_{(11)}$ - (Continued)

Name	Population served	Project requirements	Remarks
Richmond	2,680	New plant needed	- - - -
Higginsville (North Plant)	1,200	Enlarge existing plant	- - - -
Waverly	400	Needs undetermined	- - - -
Norborne	420	Enlarge existing plant	- - - -
Carrollton	3,200	New plant needed	Plans approved
Glasgow	670	Needs undetermined	- - - -
Sedalia	16,200	Enlarge 3 existing plants	Under construction
Holden	900	Enlarge existing plant	- - - -
Warrensburg	4,000	2 New plants needed	- - - -
Odessa	1,000	New plant needed	Final plans approved
Higginsville (South Plant)	1,470	New plant needed	- - - -
Sweet Springs	660	New plant needed	Under construction
Booneville	4,750	Needs undetermined	- - - -
Fayette	1,690	2 New plants needed	- - - -
New Franklin	800	New plant needed	- - - -
Columbia	26,000	Enlarge existing plant	Final plans approved
California	1,000	3 New plants needed	Planning initiated
Industrial waste (Mine)	Not known	Needs undetermined	
Jefferson City	23,000	Needs undetermined	- - - -

Table $I_{(11)}$ - (Continued)

Table $I_{(11)}$ - (Continued)

Name	Population served	Project requirements	Remarks
California (SW Plant)------	450	Needs undetermined	- - - -
Elden----------	4,700	Enlarge existing plant-----	Abatement ordered
Auxvasse-------	370	New plant needed ------	- - - -
Fulton ---------	11,500	Enlarge existing plant-----	- - - -
Chamois -------	380	Needs undetermined	- - - -
Wellsville------	1,200	Enlarge existing plant-----	Final plans approved
Montgomery City	1,600	Enlarge existing plant-----	Final plans approved
Hermann-------	2,300	Needs undetermined	- - - -
New Haven -----	800	Needs undetermined	- - - -
Washington-----	5,300	Needs undetermined	- - - -
St. Charles-----	9,000	Needs undetermined	- - - -
St. Johns-------	20,000	Enlarge existing plant-----	Planning initiated
Bridgeport -----	40	Enlarge existing plant-----	- - - -
Florissant------	300	Enlarge existing plant-----	- - - -
Nebraska:			
Coleridge ------	630	Needs undetermined	- - - -
Crofton --------	500	Enlarge existing plant-----	Planning initiated
Newcastle------	1,000	Needs undetermined	- - - -
Ponca----------	1,025	New plant needed ------	- - - -

Table $I_{(11)}$ - (Continued)

Table I$_{(11)}$ - (Continued)

Name	Population served	Project requirements	Remarks
South Sioux City	3,500	New plant needed ------	- - - -
Walthill--------	1,000	New plant needed ------	- - - -
Winnebago -----	350	New plant needed ------	- - - -
Blair ----------	3,289	New plant needed ------	- - - -
Omaha---------	180,000	New plant needed ------	- - - -
Bellevue -------	2,000	New plant needed ------	- - - -
Kennard -------	350	New plant needed ------	- - - -
Omaha (Papillion Creek)---------	60,000	Enlarge existing plant-----	- - - -
Stockyards----	720,000*	New plant needed ------	- - - -
Ft. Crook------	Not known	Needs undetermined	- - - -
Papillion-------	700	New plant needed ------	- - - -
Elkhorn--------	430	Replace existing plant-----	- - - -
Plattsmouth ----	4,000	New plant needed ------	- - - -
Nebraska City --	5,000	New plant needed ------	- - - -
Syracuse-------	950	New plant needed ------	- - - -
Auburn --------	3,500	New plant needed ------	- - - -
Central City----	Not known	New plant needed ------	Under construction
Tecumseh	1,500	New plant needed	Planning initiated
Humbolt -------	1,400	New plant needed ------	- - - -
Falls City------	5,000	New plant needed ------	- - - -

(Table I$_{(11)}$ - (Continued)

Table I$_{(11)}$ - (Continued)

Name	Population served	Project requirements	Remarks
Minnesota:			
Round lake -----	350	New plant needed ------	Final plans approved
South Dakota:			
Howard --------	1,000	Needs undetermined	- - - -
Canistota ------	600	Needs undetermined	- - - -
Marion --------	700	Needs undetermined	- - - -
Hurley---------	586	New plant needed ------	- - - -
Vermillion------	2,700	New plant needed ------	- - - -
Elk Point -------	1,500	New plant needed ------	- - - -

* Strength of industrial waste measured in terms of equivalent numbers of people.

GRAND-CHARITON RIVER SUB-BASIN

Physical Description

Geography - The Grand-Chariton Sub-Basin has a maximum width of 110 miles and a length of 175 miles, and occupies parts of the States of Iowa and Missouri. The area is approximately 11,600 square miles, which represents 2 percent of the Missouri River Basin. The natural boundaries are formed by the Des Moines River (Upper Mississippi Basin) watershed to the north, the Salt River (Upper Mississippi Basin) watershed to the east, main stem of Lower Missouri River watershed to the south and west.

Topography - The confluence of the Chariton River with the Missouri occurs at mile 227.8 and the confluence of the Grand River with the Missouri River occurs at mile 251.8. The lengths of the rivers are quite similar, the Chariton River being 280 miles in length and the Grand River 217 miles. The mean annual flow of the Chariton River is approximately 1,100 c.f.s., and that of the Grand River approximately 4,000 c.f.s. The larger flow in the Grand River is approximately in proportion to the relative sizes of the two rivers' drainage areas. The rivers themselves have been subjected to considerable canalization for the purpose of controlling flood waters. It is reported that approximately 50 percent of the length of the Chariton River has been subjected to straightening or bank improvement and consequently the original characteristics of the streams have been considerably altered.

Another topographical feature of the Sub-Basin is rolling terrain into which the streams have cut rather deep and broad valleys. The soils for the most part are of glacial origin and they range from fair to excellent in fertility. There are no extensive deviations from the prairie terrain anywhere in this Sub-Basin.

Climate - The climate is semihumid with rainfall varying between 45 and 50 inches evenly distributed over the Sub-Basin throughout the year. The temperatures are quite mild, averaging about 53 °F. Extreme temperatures do occur but at infrequent intervals.

Economic Development - The economy of this Sub-Basin is largely supported through agriculture, although there are considerable quantities of high grade bituminous coal which is easily accessible. Livestock raising for both dairying and meat production is an important agricultural pursuit. There are no extensive industrial operations, however numerous small operations, usually those concerned with the processing of food, are carried on within this area. It is estimated that approximately 70 percent of the value of all produce within this Sub-Basin comes from farm commodities and related products. Approximately 60 percent of the Sub-Basin's population reside in urban areas. There are numerous cities and towns within this Basin, however, none of which exceeds 12,000 population.

Pollution Summary

The kind and amount of pollution, together with a picture of the present control facilities and future needs, is summarized for the Grand-Chariton River Sub-Basin in tables A$_{(12)}$ through I$_{(12)}$.

Table A$_{(12)}$ indicates that the cities and towns of the Sub-Basin are small in population and that industry (footnote table A$_{(12)}$) contributing waste to municipal sewers is not a large factor to be dealt with. The statistics show that about 43 percent of the biochemical oxygen demand of municipal waste is removed by treatment prior to its discharge to the watercourses of the Sub-Basin.

Tables B$_{(12)}$ and D$_{(12)}$ indicate that industry with separate waste discharge lines is very limited, there being only one known plant in the Sub-Basin.

Table C$_{(12)}$ reveals that 78 percent of the municipalities with sewer systems have treatment plants of some type. These plants in turn serve about 74 percent of the sewered population of the Sub-Basin.

Table E$_{(12)}$ suggests that about 25 percent of the municipal treatment plants are adequately designed to meet present day needs. The table indicates that about 56 percent of the plants are receiving satisfactory operation.

Table F$_{(12)}$ indicates that one new municipal sewage treatment plant was constructed during the 4 year period beginning in 1946 through 1949. No new industrial treatment plants were known to be built during this period.

Table $G_{(12)}$ reveals that 21 percent of the sewered population is being serviced with adequate treatment. There is apparent need for 10 new sewage treatment plants, the replacement of 13 of the existing plants, and improvements of 13 other existing plants. Data on the Grand-Chariton Sub-Basin is quite complete, there being no undetermined needs.

Table $H_{(12)}$ indicates that 22 percent of the municipal projects enumerated in Table $G_{(12)}$ have been activated.

Table $I_{(12)}$ lists the project needs for municipalities and industries of the Grand-Chariton Sub-Basin. Where a new plant is indicated, the requirement may be based on the fact that no facility now exists or that the existing facility is so inadequate as to require an entirely new installation. Where enlargement of an existing plant is indicated, the requirement is based on information that existing facilities are overloaded or are otherwise not providing adequate treatment.

The project requirements listed are in some cases based on incomplete information and are subject to change after investigations have been completed by the State agency concerned.

The Grand-Chariton Sub-Basin has been the site of considerable progress in stream pollution abatement. Impetus for abatement has undoubtedly been lent by the fact that 25 of the 39 municipalities of the Sub-Basin obtain their municipal water supplies from surface sources. A greater percentage of the cities and towns of this Sub-Basin obtain their water supplies from surface impoundments and streams than in any other area in the Missouri Basin.

Water uses other than for municipal purposes within this Sub-Basin are largely confined to those of stock watering, recreation, and fish and wildlife propagation. In many instances the impoundments of water primarily designed to supply domestic needs have also functioned as sources of local recreational centers in which fishing and boating have been permitted. Bathing has not been a part of such recreational programs because of the potential danger to the public water supplies.

Table A (12) - Sources of pollution - Municipal

Municipalities*	Sources of pollution (In number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (In terms of equivalent number of people) **
Having data on pollution load discharged to watercourse	32	57, 800 ***	34, 700
Having population data available (Data on pollution load to watercourse incomplete or not available)	0	- - - -	- - - -
Total	32	57, 800	34, 700

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns, significantinstitutions, resorts, recreational centers, or other population centers; sanitary sewage wastes discharged by industry directly to watercourse. **Includes industrial wastes discharged into municipal sewerage systems. *** Data do not include industrial waste of 3, 000 population equivalent discharging to municipal sewers.

Table B (12) - Sources of pollution - Industrial*

Industries	Sources of pollution (In number of plants)	Amount of pollution discharged to watercourse (In terms of equivalent number of people)
Producing organic wastes	1	1, 200
Producing organic wastes	0	- - - -
Producing inorganic wastes	0	- - - -
Producing wastes of undetermined type	0	- - - -
Total	1	1, 200

* Industries having separate outlets and discharging wastes directly to watercourse.

Table C (12) - Existing treatment facilities - Municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	7	13	8,600
Secondary	18	26	34,400
No treatment	7	- - - -	14,800

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

Table D (12) - Existing treatment facilities - Industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and kindred products----------	1	0	1	0
Total ------	1	0	1	0

* Industries having separate outlets and discharging wastes directly to watercourse.

Table E (12) - Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	39	10	29	0	22	17	0
Industrial	0	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -

Table F (12) - Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (In terms of equivalent number of people)
1946	0	- - - -	0	- - - -
1947	0	- - - -	0	- - - -
1948	0	- - - -	0	- - - -
1949	1	3, 800	0	- - - -

Table G (12) - Requirements for municipal and industrial waste treatment plants

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	10*	18,800	1
Enlargement or additions to existing plant	13	17,100	0
Replace existing plant	13	9,700	0
No project required	10	12,200	0
Undetermined	0	- - - -	- - - -

* Includes 3 existing facilities which due to local conditions have been classified as needing new plants rather than replacements.

Table H (12) - Status of treatment works project to abate pollution - July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	27	0
Abatement ordered *	0	0
Plans under preparation	5	0
Final plans approved	3	0
Construction awaiting financing	0	0
Under construction	0	0
Status undetermined	1	1

* Formal orders to municipalities and industries for abatement of pollution have received little use as an administrative procedure in this Sub-basin. Instead, State water pollution control agencies

(Footnote continued)

Footnote for Table H (12)

have preferred to use a cooperative approach in many cases to the extent of a forced agreement to secure abatement without actually exercising police power. Formal orders are reserved for use only in recalcitrant cases where the cooperative approach is not successful. Acceleration of abatement activities in this Sub-basin may conceivably increase the use of formal orders as an administrative expedient.

Table I$_{(12)}$ - Project list - Municipalities and industries requiring improvements for abatement of pollution - July 1, 1950

Name	Population served	Project requirements	Remarks
Iowa:			
Mt. Ayr (4 plants) -------	1, 300	Replace existing plants	- - - -
Lamoni --------	1, 600	Replace existing plant	- - - -
Lamoni Packing Plant ----------	1, 200*	New plant needed	- - - -
Greenfield -----	1, 400	Enlarge existing plant	- - - -
Afton ----------	600	Replace existing plant	Planning initiated
Allerton -------	200	New plant needed	Planning initiated
Chariton (3 plants) ------	5, 000	Replace existing plants	Planning initiated
Humeston ------	500	Enlarge existing plant	- - - -
Corydon (4 plants) ------	1, 200	Replace existing plants	- - - -
Centerville (1 plant) -------	6, 000	Enlarge existing plant	- - - -
Centerville (1 plant) -------	2, 750	Enlarge existing plant	- - - -
Unionville (2 plants)-------	780	Enlarge existing plants	- - - -
Missouri:			
Stanberry ------	1, 200	New plant needed	- - - -
Grant City -----	170	Enlarge existing plant	- - - -
Gallatin -------	750	New plant needed	- - - -
Princeton ------	800	New plant needed	- - - -
Trenton -------	4, 900	New plant needed	- - - -

(Table I$_{(12)}$ - continued)

Table $I_{(12)}$ - (continued)

Name	Population served	Project requirements	Remarks
Missouri:			
Chillicothe ------	6, 100	New plant needed	Final plans approved
Lathrop---------	700	Enlarge existing plant	- - - -
Cameron -------	2, 100	Enlarge existing plant	- - - -
Milan (East plant) -----	300	New plant needed	- - - -
Milan (South plant)-----	700	Enlarge existing plant	- - - -
Marceline (West plant)-----	900	Enlarge existing plant	- - - -
Brunswick -----	900	New plant needed	- - - -
Marceline (South plant)-----	900	New plant needed	- - - -
Moberly (West plant)-----	2, 750	New plant needed	- - - -
Salisbury (2 plants)--------	1, 060	Enlarge existing plants	Final plans approved

* Strength of industrial waste measured in terms of equivalent numbers of persons.

OSAGE-GASCONADE RIVER SUB-BASIN

Physical Description

Geography - The Osage-Gasconade Sub-Basin has a maximum width of 110 miles and a length of 260 miles, and occupies parts of the States of Kansas and Missouri. The area encompasses approximately 18,800 square miles, which represents three and one half percent of the Missouri River Basin. The natural boundaries are formed by the Lower Main Stem Missouri River watershed to the north, the Meramec River (Lower Mississippi) watershed to the east, the White River (Lower Mississippi) watershed to the south, and the Neosho River (Arkansas Basin) watershed to the west.

Topography - The Gasconade River is the first major tributary of the Missouri River above its mouth. The Osage River enters the Missouri a short way above the Gasconade.

The Osage River is the larger of the two, being approximately 500 miles in length, while the Gasconade is 270 miles long. The Osage contributes an annual mean flow of approximately 10,450 c.f.s., and the Gasconade 2,985 c.f.s. to the Missouri River. The combined drainage basins lie just north of the Ozark Uplift in central Missouri and eastern Kansas.

That portion of the Osage River lying in the State of Kansas is known locally as the Marais des Cygne River. Typical of the terrain in the western portion of the Sub-Basin are the broad valleys and rolling hills of Kansas and western Missouri. The eastern section of the Osage and all of the Gasconade is much more rugged because of the influence of the Ozark Uplift. The headwaters of the rivers are located at an elevation of approximately 1,500 feet above sea level. At the point of their confluence with the Missouri River, the elevation is somewhat less than 500 feet. The Osage River is navigable for approximately 200 miles upstream from its mouth.

Climate - The climatological characteristics are those of a humid area. The annual mean precipitation is about 36 inches at the headwaters of the Osage and from 40 to 42 inches per annum over the rest of the Sub-Basin. The mean annual temperature is 55° F.

Economic Development - The economy of the Sub-Basin is largely dependent upon agriculture and its attendant service and industrial operations. There is also a considerable amount of mineral wealth, consisting of coal which is available by strip mining, natural gas and oil. It is estimated that approximately 450,000 people reside in the Sub-Basin, of which more than 50 percent are engaged in agriculture, 25 percent in trade and transportation occupation, and somewhat less than 25 percent engaged in other occupations, including professional and related services, manufacturing and mining. General farming is practiced throughout the Sub-Basin, however it is predominantly devoted to dairying with the result that the dairy industry is being rapidly developed.

Pollution Summary

A summation of the existing pollution, needs for correction, and general progress of abatement of pollution in the Osage-Gasconade River Sub-Basin, is illustrated in tables $A_{(13)}$ through $I_{(13)}$. It will be noted from the footnote of table $A_{(13)}$ and from table $B_{(13)}$ that there is a relatively small amount of industry located within this Sub-Basin, and that is located within the municipalities and contributes wastes to the municipal sewer systems rather than directly to the streams. The statistical data contained in table $A_{(13)}$ suggests that 65 percent of the biochemical oxygen demand of municipal waste is removed prior to its discharge to the streams of the Sub-Basin. There is a possibility that some industrial wastes of an inorganic nature are reaching the streams of this Sub-Basin from a small amount of coal mining operations and possibly some wastes from the oil and gas well fields located along the boundary between Missouri and Kansas.

Table $C_{(13)}$ reveals that 93 percent of the municipalities having sewer systems are provided with treatment facilities and 90 percent of the sewered population is serviced by these plants.

Table $E_{(13)}$ indicates that 60 percent of the existing sewage treatment plants have adequate capacity, and that operation of 82 percent of the plants is satisfactory.

Table $F_{(13)}$ indicates that 2 new municipal sewage treatment plants were constructed during the period 1946 through 1949.

Table G$_{(13)}$ reveals that 43 percent of the population of the Sub-Basin is connected to treatment facilities needing no further improvements. New sewage treatment plants are needed at 11 municipalities, replacement of existing plants at 2 others, and 8 existing plants need improvements.

Table H$_{(13)}$ indicates that 8 of the 21 municipal requirements enumerated in table G$_{(13)}$ have been activated and are now in the planning stage.

Table I$_{(13)}$ reveals the project requirements of the individual municipalities of the Sub-Basin. The requirements as listed are subject to change, because many of the premises upon which the requirements are based must be supported or changed when investigational work has been completed.

In the upper reaches of the Osage River the flows are low and erratic, making it necessary to treat wastes to a high degree in order to prevent local nuisance conditions. The central and lower sectors of the Osage and all of the Gasconade are highly prized recreational and game fishing areas. The protection of these stream reaches from pollution has become extremely important.

Table A (13) - Sources of pollution - Municipal

Municipalities*	Sources of pollution (In number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (In terms of equivalent number of people) **
Having data on pollution load discharged to watercourse	41	60, 400 ***	25, 600
Having population data available (Data on pollution load to watercourse incomplete or not available)	3	13, 200	Not applicable
Total	44	73, 600	25, 600

*** Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers, or other population centers; sanitary sewage wastes discharged by industry directly to watercourse. ** Includes industrial wastes discharged into municipal sewerage systems. *** Data do not include industrial waste of 12, 900 population equivalent discharging to municipal sewers.**

Table B (13) - Sources of pollution - Industrial*

Industries	Sources of pollution (In number of plants)	Amount of pollution discharged to watercourse (In terms of equivalent number of people)
Producing organic wastes	0	- - - -
Producing organic wastes	0	- - - -
Producing inorganic wastes	0	- - - -
Producing wastes of undetermined type	0	- - - -
Total	0	- - - -

*** Industries having separate outlets and discharging wastes directly to watercourse.**

Table C - Existing treatment facilities - Municipal
(13)

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	11	12	19, 800
Secondary	30	31	45, 300
No treatment	3	- - - -	8, 500

* Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers.

Table D - Existing treatment facilities - Industrial *
(13)

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
	No industries			

* Industries having separate outlets and discharging wastes directly to watercourse.

Table E$_{(13)}$ - Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satis-factory	Unsatis-factory	Unde-termined	Satis-factory	Unsatis-factory	Unde-termined
Municipal	43	26*	17	0	31	7	5
Industrial	0	0	0	0	0	0	0

* Includes one treatment plant where existing facilities have adequate capacity, but additions are needed to provide a higher degree of treatment. This need is reflected in Table G$_{(13)}$.

Table F$_{(13)}$ - Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (In terms of equivalent number of people)
1946	0	----	0	----
1947	1	750	0	----
1948	1	1,500	0	----
1949	0	----	0	----

Table G (13) - Requirements for municipal and industrial waste treatment plants

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	11*	22,900	0
Enlargement or additions to existing plant	8	17,600	0
Replace existing plant	2	1,600	0
No project required	25	31,500	0
Undetermined	0	0	0

* Includes 8 existing plants which due to local conditions have been classified as needing new plants rather than replacements.

Table H (13) - Status of treatment works project to abate pollution - July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	13	0
Abatement ordered *	0	0
Plans under preparation	1	0
Final plans approved	7	0
Construction awaiting financing	0	0
Under construction	0	0
Status undetermined	0	0

* Formal orders to municipalities and industries for abatement of pollution have received little use as an administrative procedure in this Sub-basin. Instead, State water pollution control agencies

(Footnote continued)

Footnote for Table H$_{(13)}$

have preferred to use a cooperative approach working closely with polluters in an attempt to secure abatement without exercising police power. Formal orders have in general been used only in recalcitrant cases where the cooperative approach has not been successful. Acceleration of abatement activities in this Sub-Basin may conceivably increase the use of formal orders as an administrative expedient.

Table $I_{(13)}$ - Project list - Municipalities and industries requiring improvements for abatement of pollution - July 1, 1950

Name	Population served	Project requirements	Remarks
Kansas:			
Lyndon	600	Replace existing plant	- - - -
Ottawa	9,000	Enlarge existing plant	Planning initiated
La Cygne	700	Enlarge existing plant	- - - -
Pleasanton	1,000	Replace existing plant	- - - -
Fort Scott	10,000	New plant needed	Final plans approved
Missouri:			
Nevada	5,200	New plant needed	Final plans approved
State Hospital No. 3	2,400	New plant needed	Final plans approved
El Dorado Springs	860	New plant needed	Final plans approved
Greenfield	780	Enlarge existing plant	- - - -
Stockton	100	New plant needed	- - - -
Osceola	500	New plant needed	- - - -
Bolivar	1,977	Enlarge existing plant	Final plans approved
Belton	800	Enlarge existing plant	- - - -
Harrisonville	1,600	New plant needed	- - - -
Pleasant Hill	1,510	New plant needed	- - - -
Clinton	3,740	Enlarge existing plant	- - - -
Warsaw	660	New plant needed	- - - -

(Table $I_{(13)}$ - continued)

Table I(13) - (continued)

Name	Population served	Project requirements	Remarks
Missouri:			
Camdenton -----	40	2 New plants needed	Final plans approved
Hartville ------	455	Enlarge existing plant	- - - -
Newburg -------	150	Enlarge existing plant	- - - -

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